BUSINESS MANAGEMENT

Training and Service for Executive Work

Plants and Equipment ** Control of Materials

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CHICAGO

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BUSINESS MANAGEMENT

Executive Manuals 35 and 36

PLANTS AND EQUIPMENT

—Being Executive Manual 35, on Principles of Production, in a Complete Plan of Training and Service for Executive Work

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PLANTS AND EQUIPMENT

Part I

ORGANIZING PLANT AND EQUIPMENT

IN THE first part of Executive Manual 34 we considered the organization of men and functions. Here, in Executive Manual 35, we shall consider the organization of the plant and its equipment.

Attaining low-cost production is obviously dependent upon having a well-organized plant, in its arrangement and equipment, as well as upon having a well-organized personnel. Yet the importance of organized arrangement and equipment is sometimes overlooked.

The president of a large company insisted that the handwriting of every worker be smooth and legible. Scratchy pen points were never to be used. But this executive's interest in practical equipment did not extend much further than pen points! His filing equipment, for example, was obsolete and poorly arranged. Lack of organized arrangement of equipment in general cost his company thousands of dollars each year, which could have been added to net profits had the same kind of attention he gave to pen points been extended to all his office equipment. It is well, in every business, to recognize the fact that—

> **Buildings and their layout and equipment are the tools of the businesses which they serve, and should be organized with as much care as are the human forces of business and industry.**

The advancement that has been made in organizing industrial-plant equipment is noteworthy. The industrial engineer has learned many practical lessons which can be taken advantage of in handling any management problem. Industrial-engineering principles can readily be applied in the store and the office, as well as in the manufacturing plant, to make the layout and equipment more efficient tools for the executives and the men. Better lighting, for example, will increase office efficiency as well as shop efficiency; and industrial engineering has gone far in solving the problem of having the best possible light for the men.

As we analyze the problem of industrial-plant arrangement and equipment, let us keep in mind the broad application of the principles uncovered. Much of our training for executive work will come from being constantly on the alert to see how the basic principles evolved apply in our homes, our churches, our lodges, and our other interests, as well as in our businesses.

The Industrial Engineer's Work. Many successful industries had their beginnings in rented quarters or in small buildings which were not planned with any particular care concerning the kind of work to be done in them. As these industries grew and analyses were made of the costs of production, it became evident that the influence of the design and arrangement of the buildings, departments, and equipment on the costs of production was important.

Realization of the importance of having well-organized arrangement and equipment has led many manufacturers to spend much money and time in making careful layouts of their industrial plants for the purpose of improving the present arrangement and providing for efficient layouts of future extensions and new plants.

> **Improvement along any line comes after recognition of the advantage to be gained by improvement along that line.**

Recognition of the importance of certain problems has led industrial engineers to specialize on the solution of those problems in particular. Some of them act as designers, and others as designers and contractors, making a specialty of plant layout, design, equipment; and sometimes they specialize on starting the operation of new industrial plants. These men have learned to apply certain principles that underlie success in their special fields, and they have, thru practical experience, developed ingenuity in applying these principles under varied conditions.

Let us now study the plant-layout problem as analyzed by the industrial engineer.

PLANNING THE LAYOUT

The controlling influences in designing and arranging an industrial plant are:

1. The processes or operations thru which the work must go.
2. The service equipment required to facilitate the handling of the work.

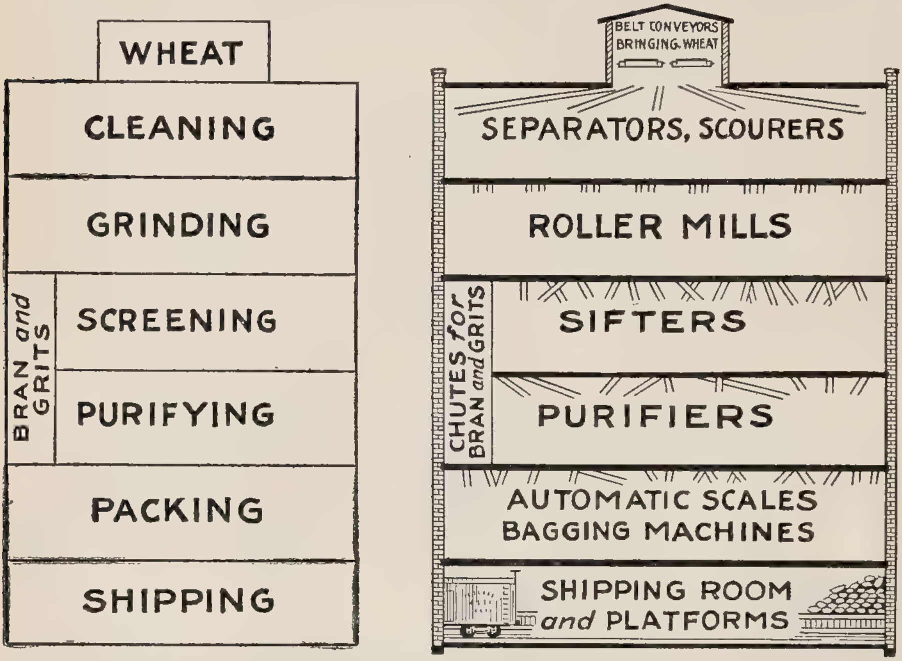
The selection of machinery and other service equipment is obviously determined by the processes thru which the material must go. The departmental arrangement and general layout, as well as the routing of the work, depend also on these processes.

The Use of a Process Map. As a first step in layout, a process map is necessary. This is simply a diagram which clearly visualizes all the main processes in operating a plant.

Figure 1 shows the process map of a flour mill—an example of analytic manufacture in which wheat is broken up into flour and such by-products as feed and grits. Figure 2 shows how this process map becomes a guide for the layout of a flour mill.

Figure 3 is the process map of a cement mill, a synthetic industry in which three ingredients—clay, limestone, and the coal used to burn the mixture—are combined to produce cement. This map gives a basis for the plant layout.

All three ingredients are to be stored, and it is generally more efficient to store each separately, where it is most convenient to the next step in its processing, rather than to plan for general raw-material storage bins. So with the grinding equipment. Usually it will prove advantageous to have four sets of grinding equipment, one for each grinding process, not only because these grinders vary somewhat in type, but also because the material can in this way flow readily from one step in the manufacturing process to the next. The main point to remember is that—



Figures 1 and 2. These figures show how the layout of a flour mill is based upon a process map of this analytic industry.

> **To get the most advantageous arrangement of buildings, rooms, and operating departments, we must first of all map the processes.**

Using a General Process Map. Preliminary general process maps are made by listing only the general operations of the industry. If these operations are all consecutive—one following the other in point of time—we list them all in one column. If some are simultaneous—carried on at the same time—there will be several parallel columns. This is illustrated in the process analysis of cement manufacture (Figure 3).

Then we can decide, from our knowledge of the processes, which of them require separate buildings and which can be housed together, and also which processes must be on the ground floor and which may be on the upper floors. For example, it is easy to decide that the blacksmith's department with its dust and fumes must be in a separate building from the machine work on the metal parts, and that large boilers must be assembled on the ground floor.

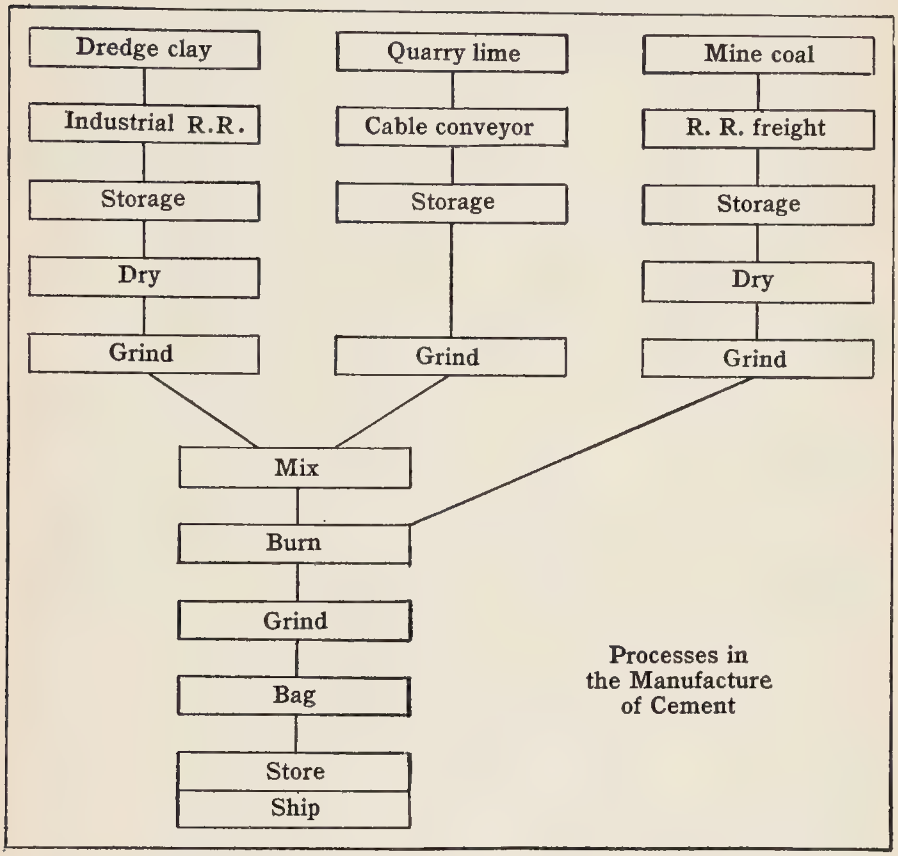


Figure 3. A process map of a cement mill, a synthetic industry, which will serve as a basis for a plant layout.

We can see how a rough sketch of the general layout of a building can be made by reference to a process map, as indicated in Figure 2, which shows the layout of a flour mill made by following the process map shown in Figure 1.

The various principal processes and the paths for the flow of materials, supplies, and work in process, as well as of by-products and waste, if any, can be indicated in colored crayons or colored inks. Next comes the problem of routing parts and material.

Routing Individual Parts and Classes of Material. Routing is different from process mapping in that it traces the path of a single part or class of material. Making a process map for an automobile factory, for example, is an entirely different task from routing a crank case from one operation to the next. To route the making of a crank case, we inspect the blue-print design of the crank case and list the separate operations to be done.

Process mapping is diagraming or outlining a bird's-eye survey of the larger flows of work in process; while routing comprises the eddies and currents and cross currents —the details of the larger flows of work in process.

A well-organized system of routing and a set of routing records covering all the detailed processes may also be diagramed in map form. These records form the basis for the list of needed equipment. But in starting a new plant, such records are not always available; then the experience and judgment of the men in charge of the production end of the enterprise form the only basis both for process mapping and for detailed routing.

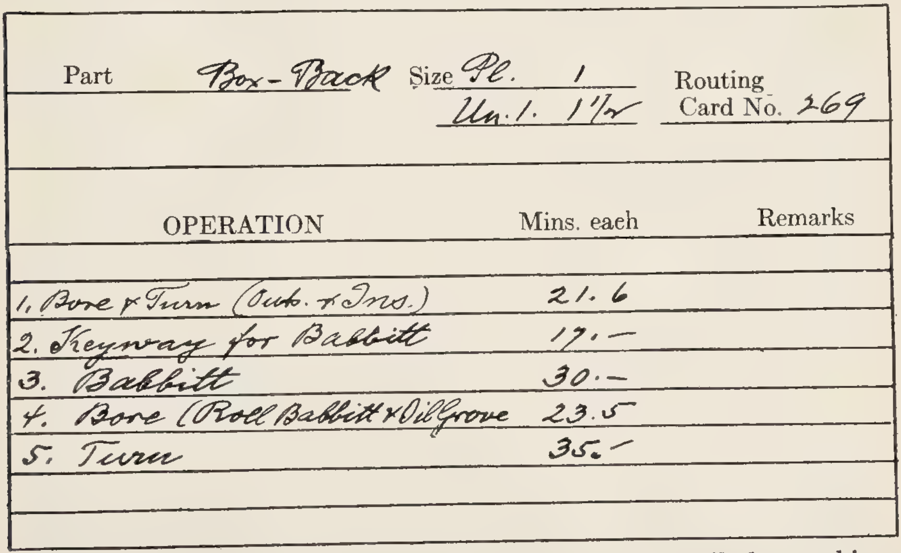
Figure 4 is a typical routing card. Note that it gives the operations to be performed on one part, and the time required for each. The industrial engineer knows just what machine tools are needed to do each operation. He also knows how many of each part must be made and can compute just how many machine-tool hours are required in turning out that number of these parts. From all the routing cards of all other parts which require an operation on the same type of lathe, he can determine the total machine-tool hours of work which will have to be done on a certain type of lathe. From this it is easy to compute the number of lathes required.

In the same way, the operations to be performed on all other machines are examined and the total machine-tool hours computed. The industrial engineer thus can proceed with certainty in planning his department layouts, for he knows what equipment must be purchased and what space must be provided for all the operations.

The Arrangement of Machinery and Fixtures. We have just seen how to determine the number of units of machines or devices required for each detailed process, by estimating the time required to process each part. In providing machinery to turn out the parts needed for a given output in a given time, we can also be guided by the number of units and the capacity for a given output as used in similar establishments elsewhere, if outside information of this kind is available.

We next investigate the floor area required by each processing machine or device; also the space required around it for operators and storage.

It is desirable to take large sheets of drawing paper, one for each department, and indicate roughly the prob-



Part Box-Back Size Pl. 1
Un. 1. 1½
Routing Card No. 269

OPERATION	Mins. each	Remarks
1. Bore + Turn (Out. + Ins.)	21.6	
2. Keyway for Babbitt	17.—	
3. Babbitt	30.—	
4. Bore (Roll Babbitt + Oil Grove	23.5	
5. Turn	35.—	

Figure 4. A routing card on which are listed in order all the machine-shop operations required to process a bearing box used on engines manufactured by this company.

able routes of material, parts, and supplies, as well as. by-products and waste, thru each department. On each sheet, we plan the arrangement of the needed processing machinery in one department; we also provide the necessary space for handwork operations.

We must also allow room for free transportation by truck, wheelbarrow, industrial railway, or crane, as well as room for probable expansion. If there is any likelihood of such expansion, and if any floor space is available for expansion, we provide for placing of additional future processing units in desirable locations.

Principles of Machine Arrangement. In arranging the locations and the positions of the various machines, two principles must be observed. The first is that—

> **Machines and other equipment should be so placed that the materials and parts in process travel as short a distance as practical between each operation and the next.**

This principle may seem too obvious to mention, but its application is an extremely important factor in attaining low-cost production. The actual placing of a machine is almost always somewhat of a compromise in which such factors as the presence of already installed equipment, the location of walls, the direction in which the light falls, the position of the drive shafting, and so on, must all be considered. Care must be taken not to give any one of these factors more weight than it deserves. Efficiency in production is continuously cut down by costly handlings of material or parts in process. The second principle, of general application, is that—

> **Work of the same character should, so far as practical, be handled in one department.**

The advantages in applying this principle, from the standpoint of supervision and of efficient use of machines, are obvious. The difficulty is that the foregoing principle of minimum travel often runs counter to this principle. The decision in such cases calls for a careful weighing of the pro's and con's—in order to determine the "so far as practical" clause in the second principle.

It may not be practical, for example, to have all the machinery used for making shafting in the machine shop. A power cut-off saw might often be profitably installed in the stores department to cut shafting to the required lengths and insure that all odd lengths are used up as rapidly as possible.

In general, it may be said that the ingenuity, the practical experience, and the good common sense of a plant executive are nowhere called upon to a greater extent than in arranging departments and equipment.

In arranging the various machines and fixtures, it is convenient to cut out forms, or templates, to scale, according to the floor space occupied by each separate machine or fixture. The name of the equipment, the horsepower it requires, and the dimensions should be written on the templates. These templates are then arranged and rearranged until the most satisfactory location in the department for each piece of equipment is found. Then the templates are fastened with tacks to the paper or board representing the department.

INTERDEPARTMENTAL ARRANGEMENT

We now have a basis for determining the approximate dimensions of the leading operating departments. It is desirable to have data from similar establishments, if available, as a check. We can cut out templates on a smaller scale, each one representing an entire department, and seek to arrange the departments in the most advantageous relation to each other so far as processing is concerned.

Here again we apply the minimum-travel principle. But before making a final layout, we have to consider the space and location requirements of the service departments and service equipment, such as storerooms, receiving and shipping rooms, tool rooms, foremen's offices, fixtures for the planning department, wash and locker rooms, transportation facilities, and so on. Let us now take up some of the more important of these service-equipment considerations.

Providing Storerooms. Storage of raw materials, of work in process, of finished individual parts, of assembled groups, and of completely finished products must be provided for by allowing space for such storage wherever it is needed. The storerooms require bins, racks, and shelves, designed and arranged to make the goods easy of access as well as safe against damage and theft, and to save floor space.

> **Storeroom spaces should be placed to avoid clogging the working part of the shop and to avoid loss or damage of parts.**

The modern tendency is to provide cribs and caging in each department in which to store the work received from other departments, also the work at rest between operations and while awaiting inspection and removal to the next department.

For raw materials and supplies, a central storeroom serving all departments is almost universally provided; also a central warehouse for storing finished products. Recently, however, industrial concerns have begun to realize how much material is lost in the shop between central stores and warehouse; and, to prevent these losses, internal departmental storage cages are coming into widespread use. The size of these cages, and the size of receiving and finished-goods warehouses as well, is decided by consideration of the nature of the material or products to be stored and the policies of the company.

Receiving and Shipping Rooms. The receiving department may be under the same jurisdiction as the purchasing and stores departments, or it may be under the shipping department. In any event, its location is usually best determined by considering its functions, irrespective of what department it may be under.

Regardless of jurisdiction, both receiving and shipping rooms must be convenient to the storerooms. Receiving will probably have to be nearer the raw-material stores, and shipping will have to be nearer the finished-product warehouse.

If many materials received and products shipped are delivered by team or motor truck, it is desirable to have these departments located where teams can conveniently get in, load or unload, turn around, and depart. In case there is but one track for carload receipts and shipments, this track will have to be accessible to both receiving and shipping departments and a clear passageway to it from both of these departments will have to be provided.

If incoming coal and outgoing ashes in carload lots constitute a considerable factor, these items will also have to be considered in laying out the trackage. Such are some of the important considerations in determining the location of shipping and receiving space.

Tool Rooms and Tool Making. Tool storage and delivery may require a messenger-boy service, a pneumatic-tube service, a cable-driven basket service, or a dumb-waiter service, as well as conveniently located storage and delivery rooms. Tool making, however, is entirely distinct from tool storage, and can usually be located off the main path of process travel.

Providing Foremen's Offices. A working-gang boss usually does not need any office or desk room. But many industries, even when provided with a planning department, require that certain foremen have privacy for studying blue prints and specifications, and for interviews.

Where a private office for a foreman serves to promote efficiency, space should be provided for it. While clerical work in the shop should be avoided so far as possible, yet an office, or at least desk room, should be provided for a departmental clerk.

Planning-Department Fixtures. A planning department usually requires room for announcements and safety bulletins, and for a dispatch board on which is listed the jobs to be worked on by each man in a department or subdepartment. The floor around this bulletin board must be kept clear and preferably fenced off by a railing. We shall consider planning boards in Executive Manual 37, where the matter of control thru planning is covered in detail.

Providing Inspectors' Quarters. Space will have to be allowed for the inspectors as well as benches and appliances to accommodate as much work in process as is likely to accumulate.

In some establishments the pieces are inspected only as they are being turned into the stock room for storing finished parts. Under such conditions only one space is required for inspectors. In other establishments inspection takes place at more frequent intervals and in various parts of the shop. In such cases, the inspectors' quarters must be located thruout the shop so as to cause least delay in the progress of materials.

Wash and Locker Rooms. It is best to distribute the wash and locker rooms about the plant instead of concentrating them in one location. This conserves the time of employes who use them during working hours. In arranging the departmental layouts, spaces must be provided for such rooms in convenient locations; and, of course, spaces must be provided for all the other service departments that have just been discussed.

Space for Transportation. We must allow room for the easy passage of trucks as well as a storage room for trucks not in use. We must also provide for modern "elevating" types of trucks loaded with material.

Aisles of ample width should be plainly marked on the floors, and the operating departments must not be allowed to infringe on this aisle space. If industrial railways (small railways inside the plant and its grounds) are to be used, space must be allowed for tracks and turntables. Room must also be allowed for trolley systems, hoists, and overhead cranes, if it is found that they are required.

The location of transportation facilities usually has much influence on the location of the other equipment.

Apparatus to Secure Correct Air Conditions. All apparatus used for heating, ventilating, humidifying, or air washing is entirely too important an economic factor in production to be left to the decision of an inexperienced architect or to a local pipe-fitting contractor. Unless there is experienced engineering skill available among the executives or employes in handling this problem of securing the correct air conditions thruout the plant, this matter, as well as the entire specifications for the factory building, should be turned over to an experienced industrial engineer.

> **The relative importance of service equipment of any kind as a factor in the efficiency of the operation of a business, largely determines the need for special skill applied to its specifications and installation.**

Consider, for example, the heating equipment. Commercial and industrial heating is done almost entirely by steam or hot water from a central heating plant. It is called direct radiation when the pipes containing steam or hot water run into the rooms and spaces to be heated. Where direct radiation is used in factories, the circulation of the steam and condensed water should be forced by other means than gravity, because the long distances traveled usually interfere with the success of the gravity return system.

Also, where direct radiation is used, a foul-air exhaust system should be arranged to remove the vitiated air at a proper rate. Such a system consists of ventilating flues in the walls connected with suction fans of required capacity.

Obviously, special skill is needed in working out the specifications and supervising the installation of a direct-heating system, largely because of the great importance of having the right kind of air of the right temperature.

Advantages of Hot-Blast System. An industrial engineer may recommend the hot-blast system, because, from a hygienic standpoint, it has advantages that often make it well worth the slight additional cost over installation of a direct-radiation system.

The hot-blast system forces fresh, warm air from a hot-air flue. This air penetrates in all directions and is better circulated than air heated by direct radiation, even when direct radiation is supplemented by foul-air ducts and an exhaust fan. Ventilating ducts and exhaust fans are also used in connection with the hot-blast system.

The greatest advantage of the hot-blast system, however, and one appreciated only within recent years, is the fact that it controls not only the temperature of the air but also its humidity. The lassitude or drowsiness of workers confined in buildings has been found to be largely due to the dryness and heat of the air.

Dry air demands a higher temperature for physical comfort. Air at proper humidity and at a temperature of 63 degrees Fahrenheit is as comfortable as dry air at 70 degrees. Hence, we can save coal and insure freedom from colds and catarrhal trouble by humidifying our air.

Humidifying or spraying apparatus is now generally sold by manufacturers of mechanical heating appliances, and it adds so much to the efficiency of the workers that nearly all progressive industrial establishments include it in their service equipment.

> **Healthier employes mean more contented employes and larger output per day. Money spent in providing equipment for conserving the health of employes is, as a rule, wisely invested.**

The only way in which heating and ventilating apparatus affects the arrangement problem is in the matter of advantageously locating radiators and registers or ducts where they will be out of the way. In the case of the hot-blast system, the air should not blow directly on workers, but it should rebound from surfaces that would otherwise be cold, such as an outside wall.

Providing Good Light. Provision should be made for having daylight as abundant as possible. This problem of having good light is so important in some cases that the entire outside walls are made up of windows and the outside surface of near-by walls is whitened so as to give a maximum of light.

Where the light must penetrate more than twenty or twenty-five feet into floors having a height of only ten or twelve feet, it is desirable to deflect and diffuse the light rays farther inside by the use of prismatic-glass panes in the upper sections of the windows. Where a building has two or more floors and the floors are more than sixty feet wide, it may be necessary to use some artificial lighting in the daytime. In single-floor buildings, or on the top floor of multifloor buildings, and where the floor is more than fifty feet wide, the saw-tooth roof, with northerly exposure of glass in the roof, gives good daylight illumination.

The position of windows has considerable influence in determining the positions of the equipment.

> **Machines, benches, desks, and all working equipment and working positions should be planned so that at least as much light comes over the worker's left shoulder as from any other direction.**

When this rule is followed there will be few, if any, disturbing shadows on the working surface and no reflected gleams to dazzle and partly blind the operators. It is also well to remember that—

> **There must be no sources of light of high intensity in the worker's natural field of vision.**

When the worker has a bright light in front of him, his eyes accommodate themselves to it. The working surface before him may be well illuminated, but he will see it with eyes partly dimmed. Eyestrain, imperfect work, and headaches are some of the penalties of intense light.

Where space and other considerations force us to put some workers where lighting conditions are not favorable, the work which requires the most continuous use of the eyes should receive the preferred location. Artificial lights, shades, and screens should be provided to make all the other locations as well lighted as possible.

Light for Different Uses. Ordinary illumination for rough work demands an intensity of light of not less than one foot-candle, which means the amount of light that would be given on a sheet of paper a foot distant from a standard candle. For reading purposes, an intensity of four foot-candles is required, and for accurate machine work, six foot-candles. These amounts of illumination are required at the working surfaces.

Intensity of light is measured by a photometer, an instrument which can be purchased or borrowed from any large electric-fixture company or lighting plant. Most lighting companies have illuminating engineers whose services are offered free of charge to all the company's customers.

For offices, reflected light, or the "indirect" type of electrolier, presenting an opaque or translucent surface to the eye and reflecting the light to a diffusing ceiling, is favored. For shops, deep, white-lined reflectors are used. For storerooms, flat distributing reflectors are used.

The spacing of the lights and their height from the floor and below the reflecting ceiling must be determined by calculation. Unless level reflecting surfaces are provided, the full indirect reflecting system cannot be used; instead, a translucent glass is used under the electrolier. This is known as the semi-indirect system.

The unprotected glaring filament is obsolete so far as intelligent illumination is concerned. It is a source of eyestrain and fatigue which materially interferes with efficiency of production, and has been superseded in the shop by the bowl type of white-enameled reflector which hides the lamp.

Power Plant and Power Transmission. Power for running machinery is of predominant importance in many industries. It must here receive some attention as related to departmental layouts.

Consideration of power plant and transmission—the power required in each department or for the plant as a whole—logically comes after the power required for light and for fans as well as for machine tools has been determined.

When belt or rope drives direct from the engine to a series of line shafts were the rule, the layout had to consider the position of these shafts and the engine had to be located to give minimum shaft lengths. Inefficient arrangement of many of the older plants reflects the influence of line-shaft-drive requirements.

Electric drive has no such limitations. The power house can be located wherever power can be generated most efficiently. If individual motor drive is used for each unit of machinery, machines can be set without reference to drive requirements; if group drive is used (one motor for a group of machines), the motor-driven shafting is, of course, placed to suit the group of machines.

Fire-Prevention, Safety, and Welfare Arrangements. The location of fire hose and hose attachments, chemical extinguishers, fire escapes, belt guards, and any other safety devices taking up space, will have to be taken into consideration in the layout.

Among welfare arrangements, those requiring space are hospitals, rest rooms, physician's office, lunch rooms, library, and assembly room.

Drafting and Designing Space. The drafting and designing space must have good daylight and be located as nearly as practical at an equal distance from (1) the commercial and sales offices, (2) the main planning-department office, (3) the pattern and drafting department, and (4) the main inspection office.

The Commercial Offices. The commercial offices used for administrative and supervisional officers should be arranged in such a manner that visitors to the purchasing department and accounting department, applicants for positions, and prospective customers can be directed into separate waiting rooms. The internal arrangement of the commercial offices should be made the subject of as careful a layout as the arrangement of the factory equipment and production departments. Office arrangement will be taken up in detail when we come to the major section of this training service on office organization and management.

THE FINAL ARRANGEMENT

After having indicated on the separate preliminary departmental sheets, and also on a large preliminary general layout, the location of all the service equipment and service departments, we are ready to make the final layout. This final layout can be visualized more completely by means of a model built to the scale of the proposed factory buildings.

Wooden floors are used in this model. The side walls are only skeleton frames. On the wooden floors are fastened (with thumbtacks) templates showing the equipment. The departmental boundaries are indicated by painted lines. The principal paths of progress of material, as determined by the preliminary process mapping, may be indicated by the use of threads of various colors.

Figure 5 shows the floor plan for a one-story manufacturing plant, made by cutting out templates representing various departments and arranging them until the most

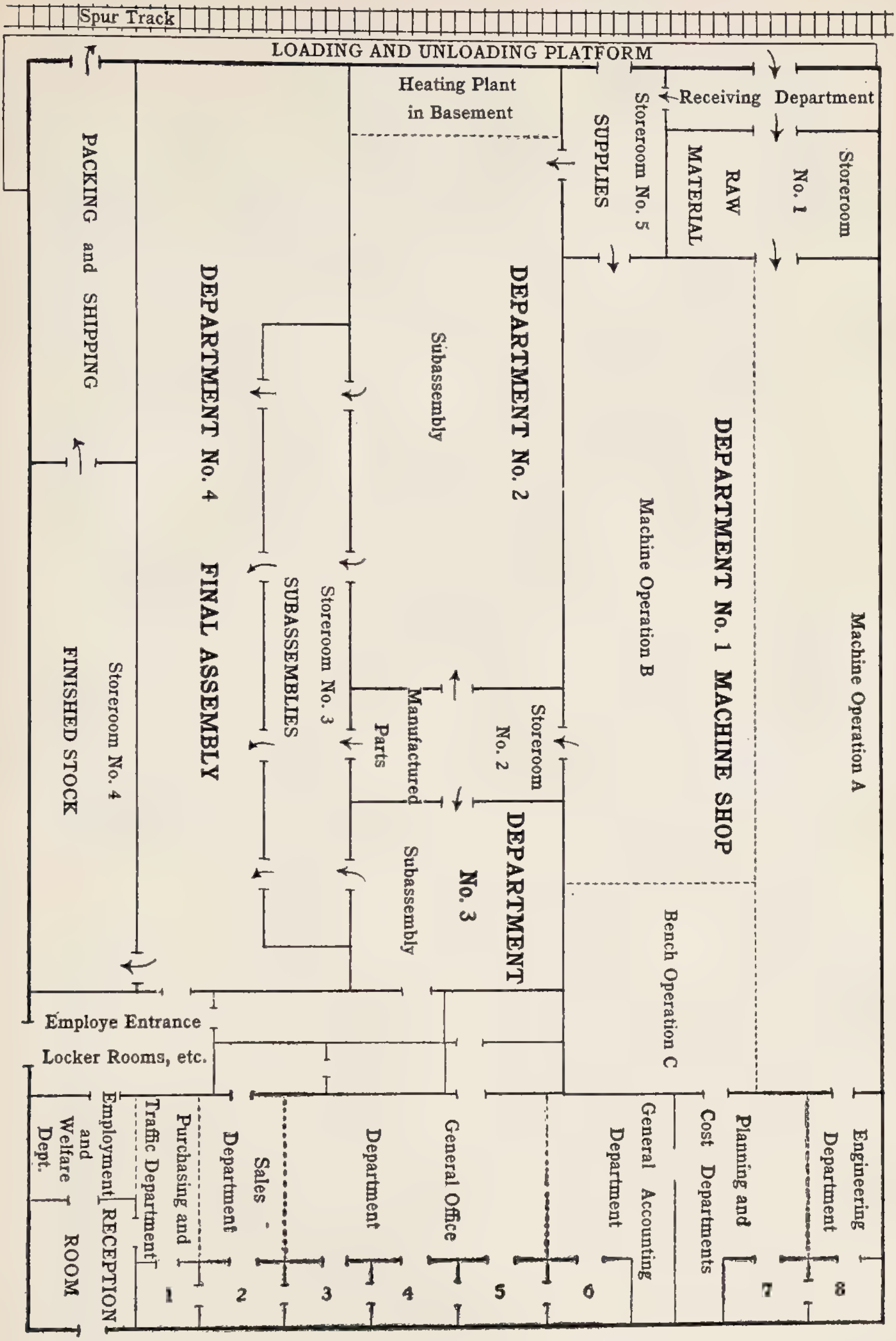


Figure 5. The layout of a one-story manufacturing plant which is lighted by windows in a saw-toothed roof. Note how the material flows from car to receiving department, and then thru storerooms, machine-shop departments, and assembly floors to the finished-goods warehouse, and finally to the shipping department. Note how efficiently each foot of floor space is used.

satisfactory location for each department has been secured.

When it becomes necessary to rearrange or change equipment in a department or shop for which a blue print has been prepared showing the existing equipment, it is customary to pin or paste paper templates showing new equipment or change of equipment on this blue print. A blue pencil is used to obliterate the white lines that show the old locations of the equipment. Photostats and blue prints can quickly be made of the rearranged layouts made in this way, thus saving time and expense in redrafting.

THE STEPS IN PLANT LAYOUT ARE:

1. A general process map.
   Are the processes analytic or synthetic?
   Are they simultaneous or consecutive?
2. A study of routings of individual parts to gain data for detailed machine lists and for departmental layouts.
3. A rough scale layout of departments.
4. A check-up of the general layout with such data as are available from other plants.
5. Adjustment of layout to provide for service departments and service features.
6. A final layout in which all factors are adjusted to gain the highest practical efficiency.

Result: A well-organized plant equipment.

BROAD APPLICATION OF ARRANGEMENT PRINCIPLES

You have seen that the controlling factors in arranging plant layouts are as follows:

1. Those relating to processes.
2. Those relating to service-equipment features.

Have you noted how true this is in store and office as well?

You have seen that the process map is the basis for plant layout and that the routing records for all the individual parts can be combined to give a basis for very definite equipment and arrangement plans. It is plain that the equivalent of routing cards may form a basis for check-up and possible re-arrangement of office and retail or wholesale store processes.

You understand how efficiency is gained by convenient travel of work, healthful working conditions, scientific lighting, prevention of damage or loss of stock, and the like. It is obvious that efficiency may be likewise gained by analyzing and planning these factors in connection with your own working and living quarters, no matter what they are.

In Part II of this manual, we shall consider time and motion studies as employed in scientific shop management. We shall learn how time studies are made and used in establishing standards of performance. It will then become apparent that the underlying principles of this phase of scientific management also apply in office or store management as well as in the shop.

PLANTS AND EQUIPMENT

Part II

Establishing Standards of Performance

ARE we routing our orders thru the shop efficiently? How much improvement is possible?

A satisfactory answer to these questions can be made only by establishing a standard of efficient routing of orders and then comparing our present system of routing with that standard.

"I've heard rumors that Jones and Drake are turning out shoes at a third less labor cost than ours. Is such a thing possible?" asked the president of a concern which faced serious price competition.

Without standards which reveal the ideal possible labor time on various operations, the works manager cannot be sure that the performance of his men is as efficient as it might be.

> **To establish standards of performance is to set up an ideal goal of results by establishing ideal methods and conditions of performance for attaining low-cost production.**

Management needs to establish standards of performance as a means of making sure that the plant and equipment, as operated by labor, yields an attainable low cost of production. Setting up standards of performance serves as a means of measuring the effectiveness of management's control of the performance of men, machines, and tools.

Standards Are Established by Research. If standards are set by guesswork, or from personal experience alone, or by any hit-or-miss method, they will in all probability fall short of ideal, practically attainable standards; they will be unreliable; and without reliable standards a company cannot estimate possible price competition on its products, nor can it measure accurately what will be the effects of proposed changes in policy or method.

How can sufficiently accurate standards be determined? The history of industry as well as of science affords adequate proof that scientific research alone will give standards which may be regarded as exact.

The experience of expert artisans is valuable in determining standards of performance. Scientific research always gives such experience a large place in its investigation. But artisans work with the tools they have, and their best work with these tools may not be as good as work done with tools that are better designed for their purpose.

> **Scientific research sets aside preconceived notions of "the only way to do a thing" and studies its problem from every angle.**

Scientific research proved than an air brush could "flow" varnish on a surface as well as an expert painter could spread varnish with a brush made of bristles.

The industrial engineer has made the shop a laboratory. He uses laboratory methods to exhaust all the possibilities and to arrive at the very best methods of doing certain work. In this way he sets up a standard with which it is safe to compare the results that are being obtained in practice.

Usually an operation in actual shop practice does not come quite up to the standard. Conditions cannot be 100 per cent all the time. Experience soon shows how close the laboratory standard can be approximated in practice —and thus the laboratory standard is readily converted into a practical, everyday working standard by which efficiencies of performance can safely be measured.

Employing Scientific Research. As pointed out in Executive Manual 33, the first four steps in applying scientific management are as follows:

1. A survey of our task and a statement of our objective.
2. Securing necessary data (facts).
3. The establishment of standards.
4. Applying the data and standards.

It is with the practical application of scientific procedure in setting up standards of performance that this manual is concerned.

In making researches which will be useful in developing standards, we must give careful attention to the following considerations:

1. The reasons for scientific research in any case: What is the purpose of the investigation? Is it practical?
2. What are the sources of the information to be secured and what methods shall be used in getting it?
3. How can the accuracy of the resulting information be checked?
4. How will the information be compiled, tabulated, assembled, filed, and indexed for use?
5. How much time and expense will the studies involve? How does this compare with the savings or profits expected as a result of the investigations?

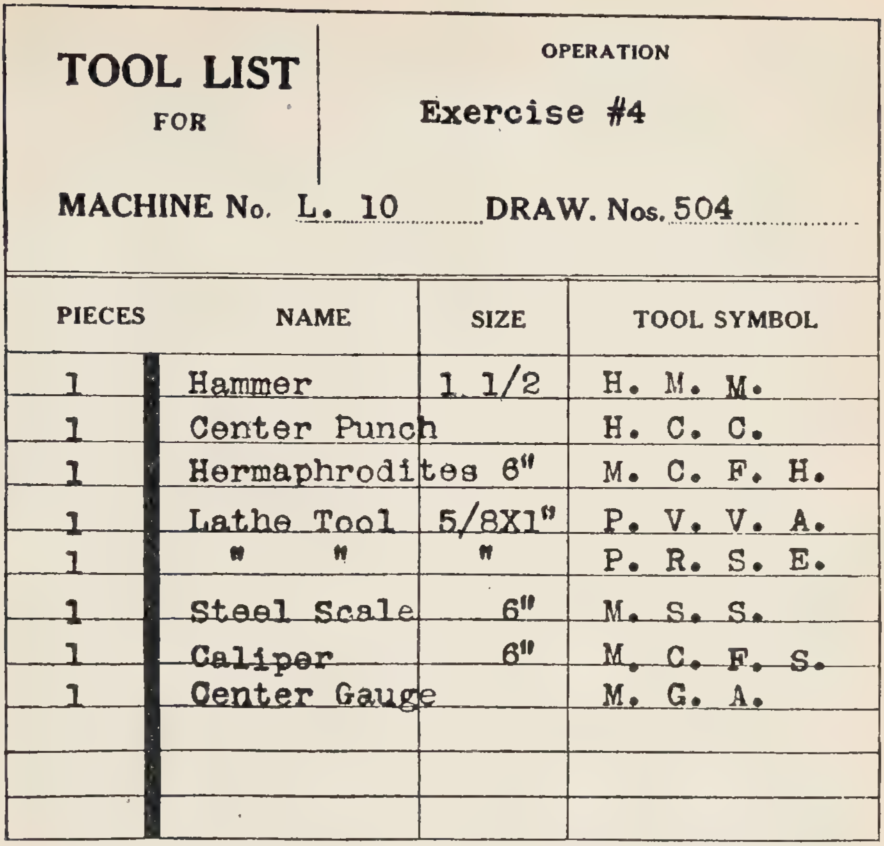
Experience has answered many of these questions. We know from experience that the greatest opportunity for savings and increased profits in production often results from rightly conducted time and motion studies, and from job analyses. We will, therefore, outline the most successful methods employed in scientific research along these lines, remembering that scientific procedure, as previously outlined, is applicable in successfully solving every important business problem.

TIME AND MOTION STUDIES

Time and motion study analyzes any process or operation into the smallest elements or parts into which it can be divided. The process may be manual or mental or on a machine. After the analysis of the process into its elements or parts has been made, each element is examined and investigated as a separate unit.

Motion study investigates the movements made in each element of a process. Its object is to eliminate all waste of time, energy, health, materials, tools, and the like.

Motion study includes consideration of such factors as experience, skill, contentment, fatigue, training, habit, and prejudice.



TOOL LIST
FOR

OPERATION Exercise #4

MACHINE No. L. 10 **DRAW. Nos.** 504

PIECES	NAME	SIZE	TOOL SYMBOL
1	Hammer	1 1/2	H. M. M.
1	Center Punch		H. C. C.
1	Hermaphrodites	6"	M. C. F. H.
1	Lathe Tool	5/8X1"	P. V. V. A.
1	" "	"	P. R. S. E.
1	Steel Scale	6"	M. S. S.
1	Caliper	6"	M. C. F. S.
1	Center Gauge		M. G. A.

Figure 6. A tool list for the piece shown in Figure 7.

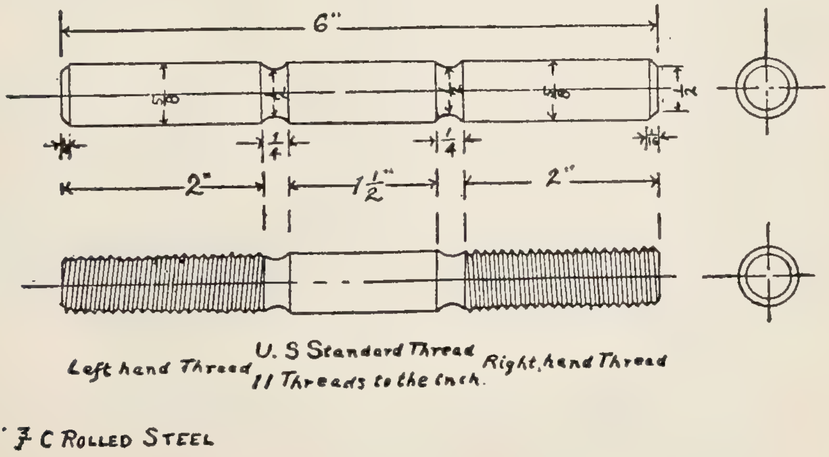


Figure 7. Drawing of piece on which time-study data shown in Figure 8 were taken.

Standard Elemental Operations and Times. "Standard elemental operations" are such as repeat themselves again and again on many kinds of work. They include such elements as the following: "Pick up tools," "walk to vise," "lay down tools," "set work into machine," "clamp work into machine," "raise work from floor to machine," etc.

It is evident that the pieces of materials or parts to be processed can be classified as to weight and shape, and that several of the elemental operations may be identical on parts of about the same weight and shape, but which differ in other respects. Elemental fastening operations can be classified according to the various sizes and styles of clamps and bolts. Raising a part from the floor may be classified as to size and weight of the part, and as to whether it is lifted by hand, by hoist, or by crane. It is apparent that—

> **Once a standard time for a given elemental operation on a given class of work has been established, it can be used on new work without a new time study.**

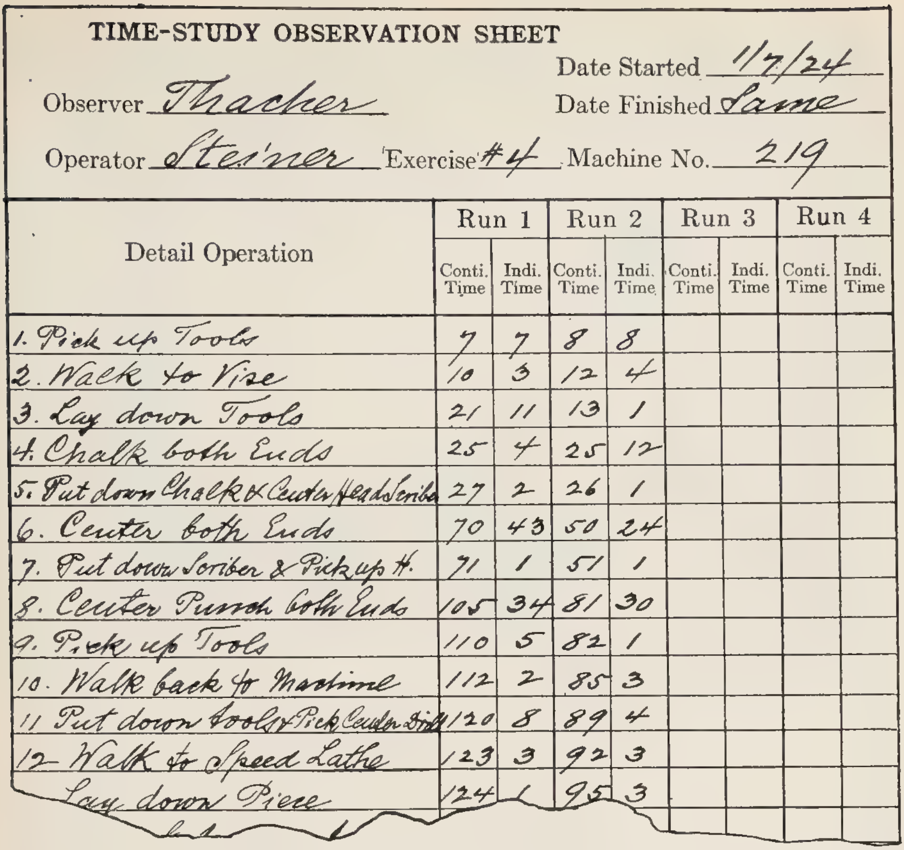
Before starting the time studies, all possible efforts should be made to standardize the procedure for bringing together the necessary material, tools, drawings, clamps, and other fastening devices, as by providing a tool list. Figure 6 shows the tool list for the work illustrated in Figure 7.

The next procedure is the listing of all the detail operations without timing them.

Figure 8 shows a time-study observation sheet, on which the broad column headed "Detail Operation" is first filled in by the observer. In some cases the operation must be repeated and observed two or three times before these details are accurately listed.

Method of Timing Observations. Figure 9 shows a board arranged to hold the time-study observation sheet, the sheet being held to the board by a clip.

At the upper right-hand corner of the board is a pro-



TIME-STUDY OBSERVATION SHEET

Date Started 1/7/24

Observer Thacher

Date Finished Same

Operator Steiner Exercise #4 Machine No. 219

Detail Operation	Run 1		Run 2		Run 3		Run 4	
	Conti. Time	Indi. Time	Conti. Time	Indi. Time	Conti. Time	Indi. Time	Conti. Time	Indi. Time
1. Pick up Tools	7	7	8	8				
2. Walk to Vise	10	3	12	4				
3. Lay down Tools	21	11	13	1				
4. Chalk both Ends	25	4	25	12				
5. Put down Chalk & Center Head Scriber	27	2	26	1				
6. Center both Ends	70	43	50	24				
7. Put down Scriber & Pick up H.	71	1	51	1				
8. Center Punch both Ends	105	34	81	30				
9. Pick up Tools	110	5	82	1				
10. Walk back to Machine	112	2	85	3				
11 Put down Tools & Pick Center Drill	120	8	89	4				
12 Walk to Speed Lathe	123	3	92	3				
Lay down Piece	124	1	95	3				

Figure 8. Time-study observation sheet. "Conti" means continuous time accumulating on each successive operation. "Indi." means the time taken on each individual (elemental) operation.

jection with cup hooks arranged to hold a stop watch. The observer starts and stops the watch with the left hand while he is taking notes with the right hand, as shown in the figure. His eyes can remain on the work except for the time it takes to glance at the watch and record its readings.

The stop watch has the minute divided into 100 divisions instead of into 60 seconds. This makes it easier to calculate the elapsed time and the individual time, as indicated in the alternate columns of Figure 8. The watch is the kind that, having been stopped, may be started again at the point at which it was stopped, and does not have to be turned back to zero. Thus it can be

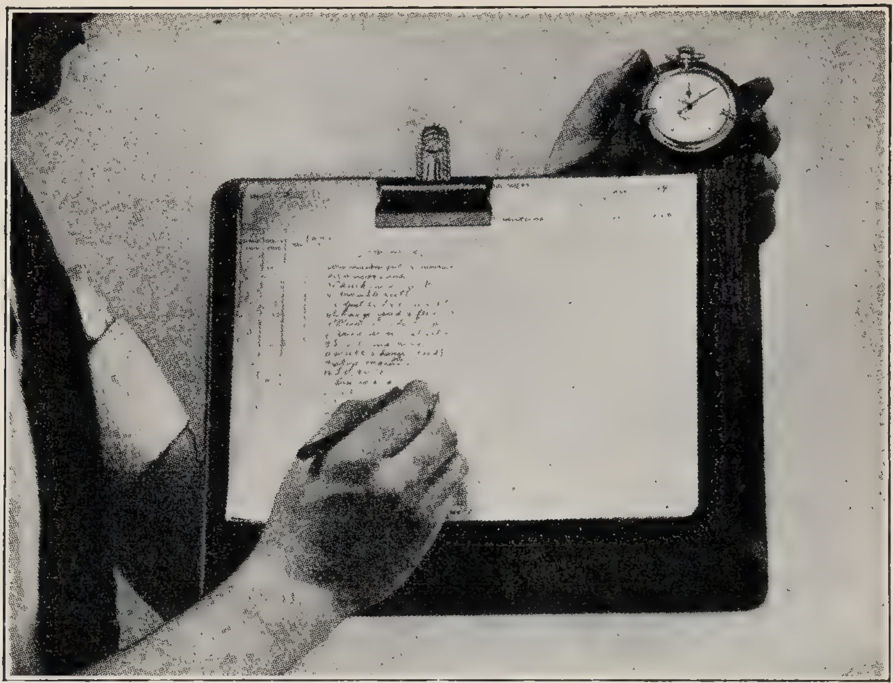


Figure 9. Method of mounting observation sheet and stop-watch on board for taking time-study observations.

stopped whenever any interruption (plainly avoidable waste of time) takes place, and started again when performance gets back to the operation being timed.

Unless there are such interruptions, however, the watch is not stopped from the beginning of the job to the end. The observer glances at the watch at the completion of each elemental operation and records the time in the column under the heading "Conti Time," meaning continuous time. (See Figure 8.) The difference between the "conti" readings gives the time taken for each elemental operation. These are computed and shown in the colunm headed "Indi Time," meaning the amount of time taken on the individual operation.

After the times of the best men at work on a particular job have been taken, each elemental operation is checked against studies of similar elemental operations. This comparison aids in studying the methods of performance with a view to effecting improvements in the methods used.

Moving Pictures as an Aid to Time Study. Frank B. Gilbreth used the motion camera with marked success as an aid in industrial research. He photographed the mechanic at work. Every movement was recorded on the film. A specially designed clock was placed so that it appeared in the picture and the exact time taken by every movement could be seen.

This clock has a dial about 30 inches in diameter. On the dial is a pointer which makes 10 complete revolutions a minute. The dial is divided into 100 parts, each representing one thousandth of a minute.

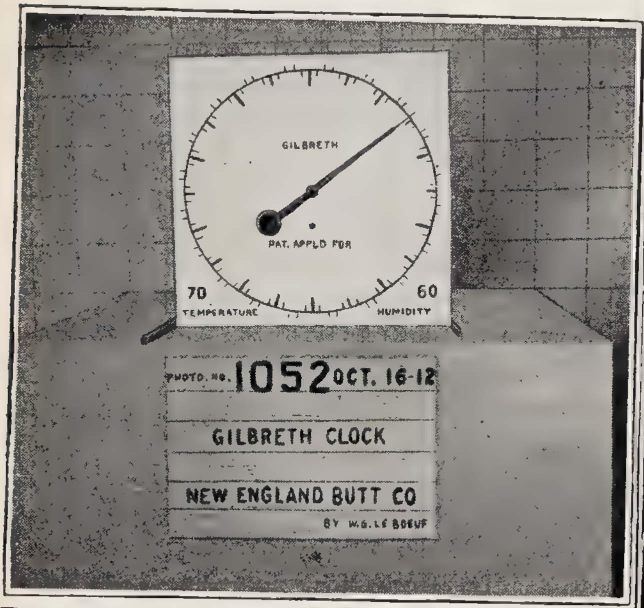


Figure 10. This Gilbreth clock, used in motion-camera study work, records 1/1000th of a second and shows the exact time taken by every motion made by the workman.

Figure 11. At the right is a motion-picture film showing an assembler reaching for a part. Note the cross-hatched background and the Gilbreth clock which times the operation.

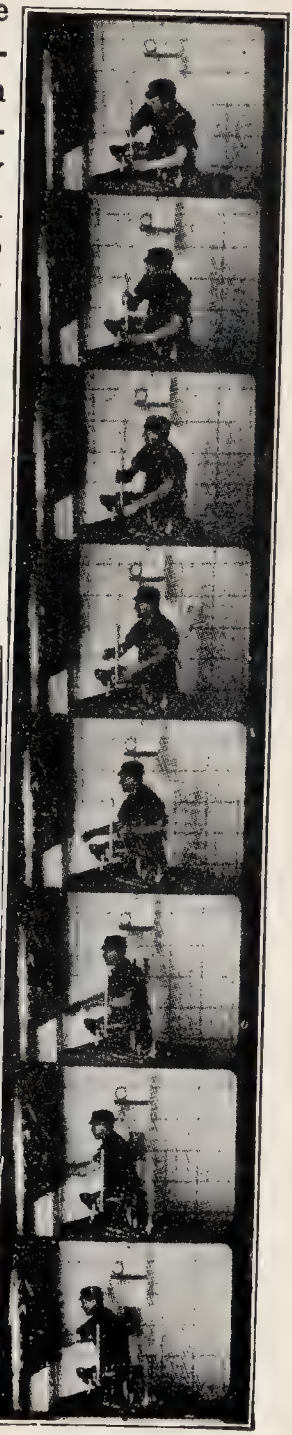


Figure 11.

When a workman reaches out his hand to pick up a tool, the pointer on the clock in the picture shows the time at the beginning of the movement. It shows in another position at the end of the movement. Thus the exact time of the movement is ascertained. An exact and permanent visual record of the movement is secured.

Every motion of the workman is so clearly shown, and can be so readily and repeatedly studied, that the finding of new and shorter ways of doing the job is thereby greatly facilitated.

Figure 10 illustrates the clock used in motion-camera-study work and Figure 11 shows a typical set of motion pictures taken at the New England Butt Company. It will be noticed that the floor and background are cross-sectioned so as to make it easy to measure the motions and surrounding conditions. On the cross-sectioned background, the heavy lines are twelve inches apart and the light lines four inches apart. An inspection of the pictures shows that it takes a man one second to let go of the work he is doing and get his hands to the assembling board.

The moving-picture machine was thus used by Mr. Gilbreth to analyze the motions. Close study of the films would usually show that a great many of the motions of a workman are wholly unnecessary, and also that a great deal of useless work was done in picking up pieces from boxes and trucks on the floor.

It is evident that if pieces to be assembled are well arranged on an assembling board, they can be reached for and put into position in a much shorter time. There are various styles of assembling boards, similar to that illustrated in Figure 12, upon which another worker, such as a stock-room boy, places the various light parts of machines to be assembled. Then, when the expert mechanic assembles the machine, the use of the assembling board eliminates a great deal of the time formerly lost in bending down and stooping over.

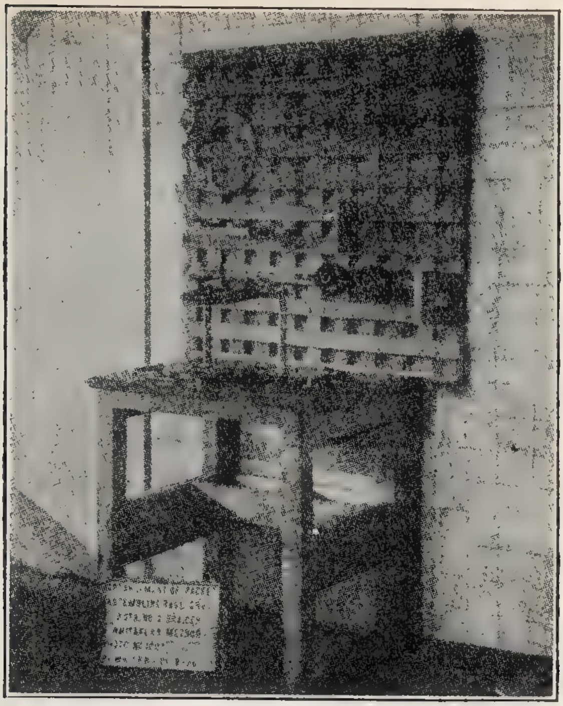


Figure 12. The rack from which the workman assembles the different parts of the machine he is making. A stock-room boy puts all the parts needed to assemble one machine in their proper places on this rack. A supply of filled racks is always at the assembler's side, ready for use as fast as each machine is completed.

Mapping Motions. Another device, used by Mr. Gilbreth in studying rapid motions that are frequently repeated, consists of attaching a small electric-light bulb to the hand of the operator, the bulb being connected by flexible wiring with a battery or other source of current. The light in the vicinity of the operator is slightly darkened so that the electric light on the hand rather than the picture of the man and machine will be recorded on the photographic plate. The camera is trained on the worker as he performs the operation which is under investigation. The plate is exposed long enough to get pictures of several complete paths of motions.

When the plate is developed, it shows a line or lines of

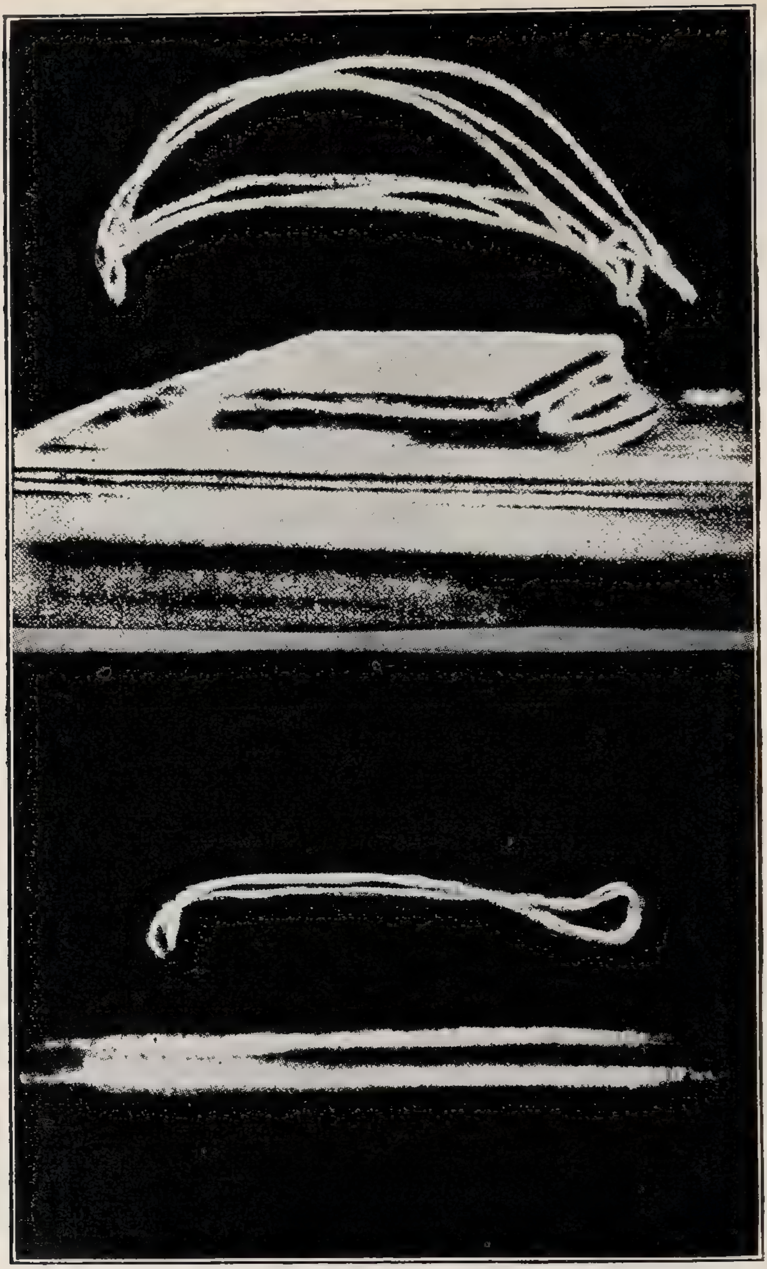


Figure 13. The upper picture is a motion-picture record or map of the movement of the hand of an operator who is putting sheets from a pile onto a moving belt. The lower picture shows the same operator after his hand has been trained to follow the shortest path. The result was greatly lessened fatigue.

light traced in an irregular path. The figures of the man and machine may be faintly visible, but they do not count. The main thing is the path made by the light, which is a record or map of how the operator's hand moved in the operation. Figure 13 shows this record or map in one case. The top picture shows three of the completed movements (one line for each movement) before this movement was improved and standardized. By study of the movement as shown in the top picture, it was possible to standardize it, avoiding waste motion, as shown in the lower picture of Figure 13.

It is often found that the path of a movement thus photographed is not a straight line, but is a more or less complicated curve. A straight line would be shorter. The problem then resolves itself into providing or arranging fixtures, stands, or tools so that the path may be shortened, and also in training the workman in new habits of motion.

When such a record of a movement showed a path full of twists and angles, Mr. Gilbreth reasoned that something must be the matter with the arrangement of the parts which the hand must reach. For example, one record showed that the operator of a certain machine had to reach a considerable distance to seize a certain lever. The operation had become habitual, and even the trained eye of the efficiency expert had failed to note that there was any unnecessary movement. The photographic record, however, showed that this reaching resulted in some loss of time. The mechanism of the machine was altered so that the lever was within short reach of the workman's hand.

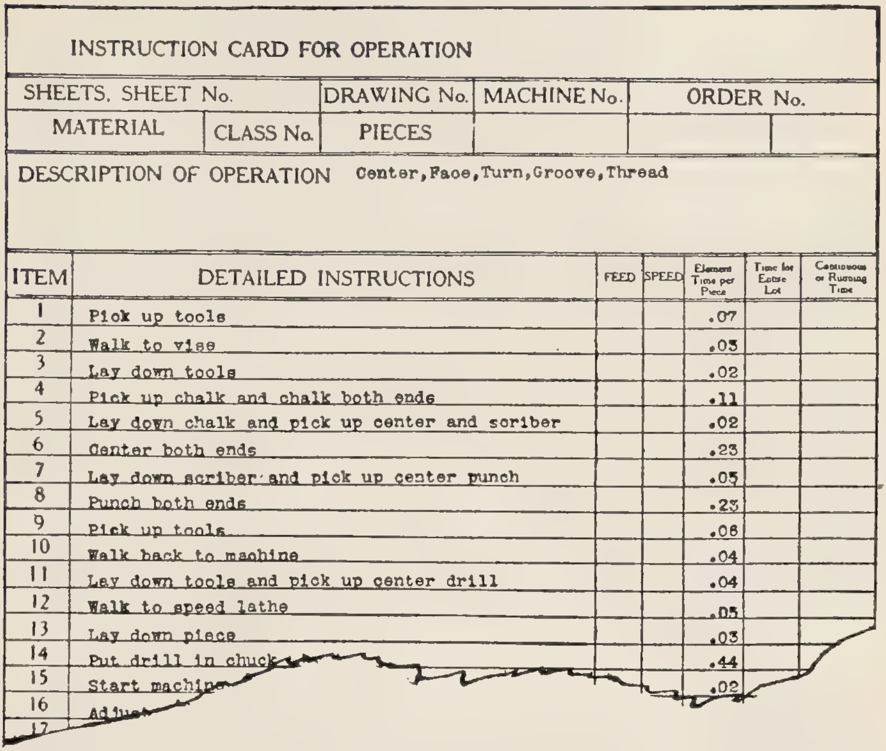
Observation and correction of only slight wastes of motion yield important savings of time and effort in the aggregate, especially so when the same motions are repeated many times during the day.

In order to introduce the time element, Mr. Gilbreth added a disc whose revolutions make and break the current which lights the lamp on the operator's hand. Then, instead of a continuous line or band, the photograph shows a line of dots and dashes. By gearing the disc to a definite speed, the number of flashes shows the time the motion has taken. The shape of the flash, blunt at one end and sharp at the other, shows in which direction the motion is made. Mr. Gilbreth designated these maps or records of motions as cyclegraphs, since they graphically record the complete cycle of motion.

Requirements for Time-Study Observation. It is desirable, altho not absolutely essential, that a time-study observer be trained in the trade which is under observation. He need not necessarily be an expert. But he should be patient, diplomatic, and unprejudiced. Laboratory experience in which a man has become accustomed to taking accurate readings is good preparation for this work, provided it has been followed by some shop training in the trade in which the time studies are made.

The workman on whom the time study is made should always be informed of its purpose; his interest and co-operation must be secured. Time study for the purpose of getting the motion and time elements should always be made on first-class men. Then, in establishing a standard time as the basis for a wage scale, a percentage of extra time should be added to the amount of time required by the first-class men. This is done in order to give the average man on the job an incentive to meet the standard, because he finds that it is attainable.

It is customary to pay a workman an advance over his ordinary rate of pay whenever he co-operates by acting as a subject for time and motion studies. This extra pay is in no sense a bribe, but rather a bonus in recognition of his co-operation with the time-study man. Furthermore, the workman may be called upon by the time-study man to stop suddenly in the midst of a process, to think about certain motion elements involved, and discuss whether these elements are ordinary practice; to advise whether a certain improvement, short cut, or device suggested by the time-study man is feasible or not; or to assist in many similar ways. Co-operation of this sort requires more than average ability.



INSTRUCTION CARD FOR OPERATION

SHEETS. SHEET No.		DRAWING No.	MACHINE No.	ORDER No.	
MATERIAL	CLASS No.	PIECES			

DESCRIPTION OF OPERATION Center, Face, Turn, Groove, Thread

ITEM	DETAILED INSTRUCTIONS	FEED	SPEED	Element Time per Piece	Time for Entire Lot	Continuous or Running Time
1	Pick up tools			.07		
2	Walk to vise			.03		
3	Lay down tools			.02		
4	Pick up chalk and chalk both ends			.11		
5	Lay down chalk and pick up center and scriber			.02		
6	Center both ends			.23		
7	Lay down scriber and pick up center punch			.05		
8	Punch both ends			.23		
9	Pick up tools			.06		
10	Walk back to machine			.04		
11	Lay down tools and pick up center drill			.04		
12	Walk to speed lathe			.05		
13	Lay down piece			.03		
14	Put drill in chuck			.44		
15	Start machin			.02		
16	Adjus					
17						

Figure 14. The first part of a three-sheet instruction card on which over one hundred elemental operations are listed. This card is the final result from the time studies shown in Figure 8 on the piece shown in Figure 7.

Preparation of the Instruction Card. Figure 14 shows part of an instruction card made up from the results of the time study previously shown in Figure 8. It will be noticed in this instruction card that each element of the operation is listed, and that the standard time for performing each element is set down. All the elemental operation times, when added together, give the "time basis" for the complete operation.

> **Complete operations are broken up into their elements in order to examine each element by itself, standardize it, and then reassemble the elements into a more nearly perfect whole.**

The "time basis," which is the sum of the standard times of all the elemental operations, is by some industrial engineers termed the "standard time" for the job. In computing standard time, however, a majority of industrial engineers add a percentage of time to the "time basis" to allow for average performance, as previously explained.

After the time-study work has progressed to such an extent that standard times have been listed and filed for a variety of standard elements of operations, the building up of the instruction card for a new operation will consist largely of assembling standard elements whose standard time is known, leaving only a few elements remaining whose time has not previously been standardized. Even for some of these remaining elements it may be possible to figure the time from known data without the necessity of time study. Thus the need of actual time-study work in the shop becomes less as more and more standard elemental operations are carefully timed and the results are indexed and filed for reference.

Getting the Work Done According to Instructions. Where the men have never worked under instruction cards, patient and systematic training is required. It is necessary to insist that the instruction card be carefully read and that the individual steps or elements of the operation be followed. Tact and patience are the more necessary because men who have been accustomed to looking at the time consumed on a job merely in the light of the total time are at first likely to consider as impossible the time reductions indicated on most instruction cards.

In one case, after considerable preliminary work in planning and getting materials and tools ready and after careful time studies, it was decided to offer a bonus to a group of automobile assemblers if they made a standard time of 100 hours for a certain job. The best previous record made on this job had been 225 hours, and the men naturally felt that it could not be done in 100 hours. But thru careful instruction and handling of the men, the time was reduced to 90 hours, and ultimately it was a common occurrence for the total assembling of this job to take no longer than 65 or 70 hours.

It is essential that a skilled demonstrator or leader remain with the workers until they are able to do the tasks specified on the instruction cards within the time limits designated. When a job is being done continually in the time specified, it can safely be left alone. When a new man undertakes a certain task, it takes a much longer time than is taken by the trained men. Then the services of the demonstrator or leader will probably again be required.

Allowances for Exceptional Conditions. Where there is a difference in the quality of material—as found in cast iron or cast steel, in which three degrees of hardness are usually recognized—a definite schedule in machine speeds and feeds should be agreed on and the consequent changes in the standards of time should be shown on the instruction sheet. Where there is a functional foreman in charge of the feeds and speeds, he will be the man to pass judgment on the quality of the metal. Where there is no such supervisor. the foreman will make the decision. Thus—

> **Scientific management in setting standards of performance makes due allowance for all uncontrollable variations in conditions which affect the time required in doing a job.**

In setting a standard time, no allowance is made for cleaning a machine while the work is in process or for any oiling not specified on the instruction sheet. Any delay for making a necessary repair should be approved by the functional repair boss, if there is one, or by the foreman.

Time Study Does Not Mean Driving. Industrial engineers know that the worker must not use too much strength and vitality in his work. This is important. Scientific time study recognizes it.

Conservation of the worker's strength during the day and avoidance of undue fatigue are important objectives of scientific management.

In some classes of work, rest periods must total one or two hours a day; in certain other classes of work, rest periods take up as much as one-half of the total working time.

In order to avoid fatigue it is necessary to know how long a man should work between the rest intervals and how frequently the rest periods should come. It may be known, for example, that a skilled drop-hammer blacksmith needs to rest about one-half of the working time, but it must also be known whether it is best for him to work five minutes and rest five minutes, or to work ten minutes and rest ten minutes, or with some other combination of work and rest periods. This information can be gained only by careful experiment.

Office workers also require rest periods. Work at too great a pressure and too long continued, or in unfavorable surroundings, is never efficient work. Time studies made on office workers often show methods which lighten the strain on the workers and at the same time get out more work.

Work under conditions which cause undue strain not only impairs the workers' health, but tends to impair the company's profits.

It must also be borne in mind that interest in one's work lessens fatigue. A man's mental attitude toward his work means a great deal. The development of the right mental attitude toward the work and the company is an important problem that will be fully treated in the section on managing men.

Scientific tests have been worked out to determine the frequency and length of pauses and rest periods. But the common sense and good judgment of an experienced observer, who studies the methods pursued by those workers who get out the most work with the least fatigue, will usually prove just as valuable in deciding these questions, since fatigue varies with physical and mental differences in workers as well as with their training, occupation, surroundings, and so on.

A change in position will frequently prevent fatigue. Special stools have been devised with foot and back rests, so that the position is easily changed. These are useful in the office as well as in the shop. The problem of fatigue is worthy of careful study in every business. One of the primary aims of applying scientific methods in production is to prevent fatigue from undue strain.

The Need of Inspection. A thoro system of inspection is necessary with any system which uses instruction cards, time standards, and bonuses; otherwise, the standard of workmanship will fall off. Floor inspectors often accompany the move-material men as they transfer work in process from department to department, these men moving only such work as is approved by the inspectors.

The Value and Cost of Time Study. Manufacturers sometimes feel that the cost of time studies in their plants would be excessive in relation to returns. This may be true in some cases, particularly in the smaller plants. But in many of the larger plants of the country, time study has given large returns both to the men in the form of higher wages and less fatigue and to the management in the form of lower costs per unit of output.

It is important to remember that the fundamental principles of scientific management may be, and should be, successfully applied in small as well as in large establishments, and not only in production but also in the office, the warehouse, and the mercantile establishment. Standards of performance, for example, can be set up for almost every operation in any business, large or small—even tho it may not be advisable in every case to set up these standards by means of time study.

The cost of time studies, however, must be considered in light of the fact that the results of one time study covering a standard operation may be applied to all similar operations, as previously explained.

Let us now briefly consider the problem of attaining higher standards of performance by fitting the worker to the job thru job analysis.

JOB ANALYSIS

The results aimed at by personnel managers have led to the development of job-analysis research.

The personnel managers found "misfits" in industry and they asked the industrial engineer where these men could work efficiently. As heads of the employment departments, they asked for more exact descriptions of the workers they were instructed to employ.

"How can the job best be done?" was the question answered by time and motion studies. "Who can best do the job?" is the question that is answered by job-analysis research.

Investigation in Job Analysis. In job analysis each job is given a definite name and then is investigated as to—

1. The exact nature of the work to be done.
2. The conditions under which it must be done.
3. The best methods and standards for doing the work, as determined by time, motion, and fatigue studies. (We consider here the tools, material, and machinery used; the kinds of operations; and the motions in each operation.)
4. The human qualifications that are necessary to do the job effectively.
5. The training or experience required in the worker.
6. The wages paid for the proper performance of the work.
7. The possibilities of promotion.

When such an investigation is made by a man who can expertly determine what qualities a worker must possess to be happy in a job and to do it efficiently, a long step has been taken toward fitting the job to the worker. Then we know accurately and fully the qualities required in the worker to fill that joo, and our problem is to find a worker with these qualities, who, with a little training, will fit the job.

The Need for Job Analysis. The importance of job analysis is evident, because jobs vary widely in their requirements of physical and mental characteristics in the men who can most successfully handle them.

Certain jobs calls for muscular effort which is merely healthy exercise for some men, but which would greatly fatigue most men of slighter build. Some types of minds are supremely content with work which other types of minds would find uninteresting and monotonous.

In most communities, workers can be found with qualities that fit all the available jobs. It is largely a case of finding, among available workers, the right man for the job. Let us remember that—

> **Management not only insures itself contented and efficient employes but performs a distinct social and economic service when it selects workers who are well qualified for their jobs.**

Figure 16 illustrates a typical case of thorogoing job analysis. Figure 15 is a large factory's job-man specification form used to describe the type of worker needed. This is sent to the employment department for its guidance in selecting the right man for the job.

How Job Analysis Classifies Workers. The traditional method of classifying workers has been refined as a result of job analysis. In classifying machine-shop mechanics, for example, the traditional method designated a man simply as a lathe hand or a drill-press hand, or the like, with no further classification. But scientific job analysis reveals distinct grades in lathe work, drill-press work, and so on, each grade requiring more skill, mental ability, and experience than the next lower grade. For example, on the following page is a classification of workers in a modern lathe and planer department.

Class A. Leaders in charge of groups; men who have a general knowledge of manufacturing operations, methods, and material used and who have judgment, accuracy, and a high degree of skill and dependability. Examples are engine-lathe, planer, and boring operators for large work, where mistakes result in great loss.

Class B. Accurate, dependable workers with considerable ability and experience, but without the general knowledge and the experience required of those in Class A. Class B workers are generally operators on accurate or heavy work which usually calls for repetition. Examples are engine-lathe operators doing not especially accurate but laborious work, and planer operators on medium-sized work with much repetition.

Class C. Workmen who have become proficient on work which is usually repeated. Examples are engine-lathe operators on repetitive work; planer operators on rough work; boring-mill operators on repetitive work.

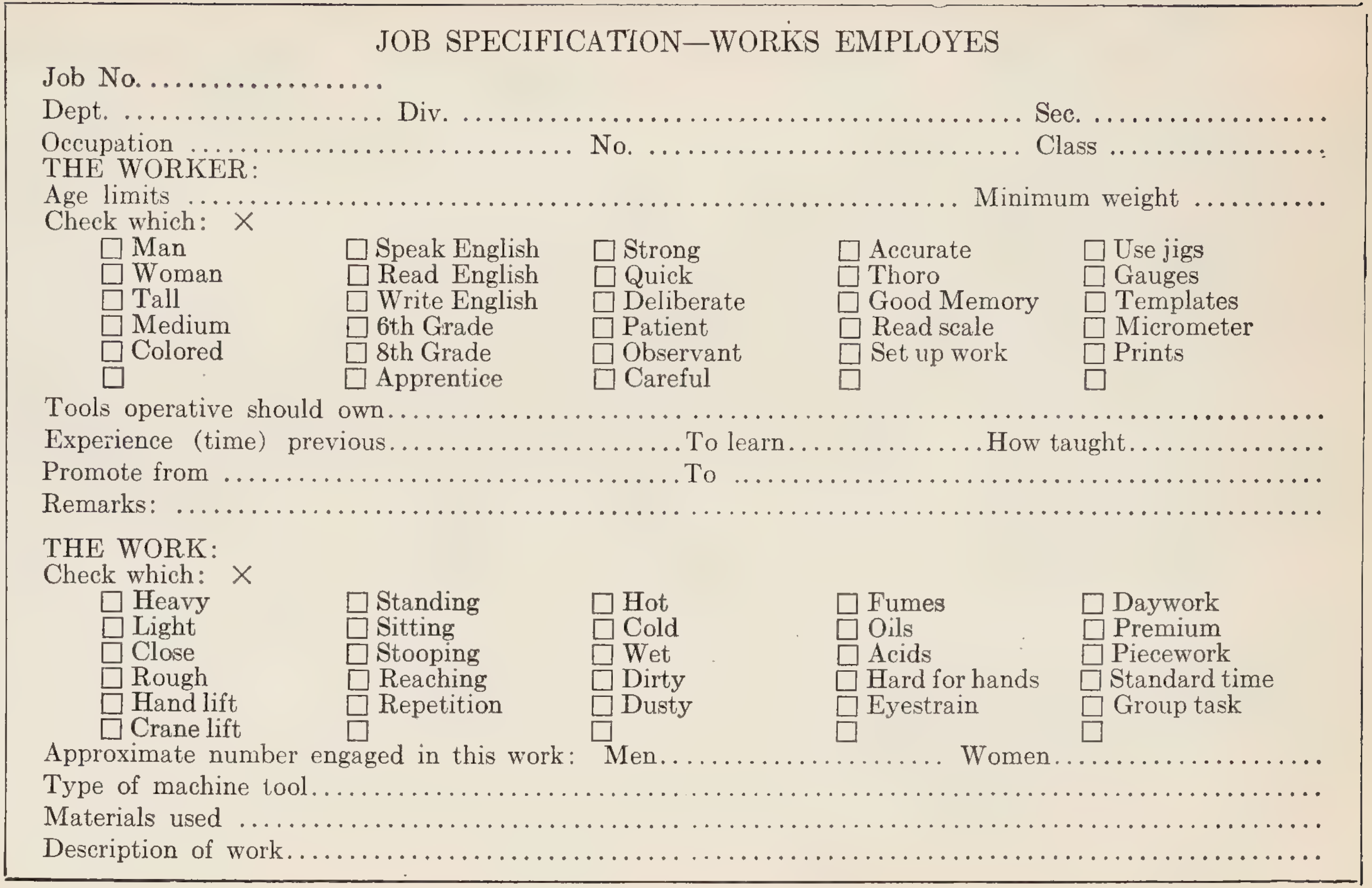
Class D. Workmen who can be taught in a short time to become efficient producers on work which is usually repeated. Examples are employes learning to operate engine lathes, planers, and boring mills.

Class E. Unskilled workmen, with little if any previous training, who do work requiring a small degree of skill, accuracy, and knowledge. Examples of unskilled workmen are truckers, sweepers, material handlers, and machine helpers.

The grades of workers as above classified correspond in a general way to first sergeant, sergeant, corporal, private first class, and private, in army life; or the above classes of shop workers may be compared with apprentice salesman, junior salesman, salesman, supervisor, and district representative, as found in the sales department of some large business organizations.

A classification of the workers from the standpoint of their qualifications and of the work they are able to perform acceptably gives a fair basis for differences in wage scales and in opportunities for promotion. The men should be encouraged to train themselves for advancement from one class to the next. The door of opportunity should always stand open.

Job classification provides a ladder with consecutive steps up which the ambitious worker can climb.



JOB SPECIFICATION—WORKS EMPLOYES

Job No. ....

Dept. .... Div. .... Sec. ....

Occupation .... No. .... Class ....

THE WORKER:

Age limits .... Minimum weight ....

Check which: ×

☐ Man
☐ Woman
☐ Tall
☐ Medium
☐ Colored
☐

☐ Speak English
☐ Read English
☐ Write English
☐ 6th Grade
☐ 8th Grade
☐ Apprentice

☐ Strong
☐ Quick
☐ Deliberate
☐ Patient
☐ Observant
☐ Careful

☐ Accurate
☐ Thoro
☐ Good Memory
☐ Read scale
☐ Set up work
☐

☐ Use jigs
☐ Gauges
☐ Templates
☐ Micrometer
☐ Prints
☐

Tools operative should own...

Experience (time) previous........................To learn...............How taught...............

Promote from ....To ....

Remarks: ....

THE WORK:

Check which: ×

☐ Heavy
☐ Light
☐ Close
☐ Rough
☐ Hand lift
☐ Crane lift

☐ Standing
☐ Sitting
☐ Stooping
☐ Reaching
☐ Repetition
☐

☐ Hot
☐ Cold
☐ Wet
☐ Dirty
☐ Dusty
☐

☐ Fumes
☐ Oils
☐ Acids
☐ Hard for hands
☐ Eyestrain
☐

☐ Daywork
☐ Premium
☐ Piecework
☐ Standard time
☐ Group task
☐

Approximate number engaged in this work: Men........................ Women..................

Type of machine tool..

Materials used ....

Description of work..

Figure 15. Even tho your concern may not be using a standardized printed form for listing the qualifications that workers must have in order to fill the requirements of certain jobs, this form, which is used by one manufacturing concern, will give you a good idea of the essential points to include in a request for men or women workers.

JOB ANALYSIS

1. **Name of job** . . *Press Operator* . . . *Punch-Press Department* . . .
2. **Description of job** . . . .
   Operating single-action punch, or stamping press. The operator feeds sheets, strips, or pieces of tin plate, or ends for other parts already cut or formed, between die and punch, and operates the press by tipping a treadle on the right side. She does not adjust nor set dies and has no responsibility for the maintenance of the equipment; but she must be on guard against causing injury to the dies by improper feeding, and must watch the finished product for the purpose of reporting at once to the foreman any defective work turned out by the machine, so it can be remedied.
3. **Female** . . . .
4. **Starting rate** . . . . cents per hour . . . .
5. **Advancement** . . . . cents per hour after 1 month's service.
6. **Average earnings,** piecework . . . . per day . . . .
   to . . . . per week.
7. **Nine hours per day,** 50 hours . . . . per week
   (7 to 12; 12:30 to 4:30.)
8. **Analysis of work:**
   - (*a*) Operator stands or sits, depending upon the size of the machine and the job she is placed on.
   - (*b*) Work is active and quick, but no heavy lifting is required, as tin plate is placed in position by trucker.
   - (*c*) Work is done by daylight, with plenty of light entering from the windows on both sides of the department. Additional illumination is furnished by lights behind press, which are placed so as to prevent blinding the operator.
   - (*d*) Ventilation is accomplished solely by opening the windows on both sides of the department, which gives an air current, but is good on account of the size of the floor space.
   - (*e*) Temperature is not influenced particularly by any machine process in the department. In the winter the department is well heated.
   - (*f*) Cleanliness: Work is fairly clean with the exception of the dirt caused by the lubricant and oil used in drawing operations on press, which will soil the clothing and shoes of operators working on that type of work.
   - (*g*) Operations are of repeated type; the operators often change from press to press on different jobs.
   - (*h*) The surroundings are pleasant.
   - (*i*) No particular hazard to health, with the exception that operators without physical stamina or with predisposition to disease will not be able to stand the work very long.
   - (*j*) Accident hazards: Machines are well guarded with new Canco guards. Operators must be warned against placing fingers under die or punch at any time, and should be instructed to use the wood sticks and hooks placed at each press, and to remove any particles from die, and to call

Figure 16. A typical job analysis, showing the details which it is desirable to consider in even so apparently simple a matter as the selection of a girl to operate a punch press. The particular form is

the die setter or foreman if they notice any trouble with their machine. Should be instructed against placing arms around and behind the die to catch trimmings for the purpose of inspection, as many serious accidents have been caused by this practice. Should be instructed never to operate press if it is out of order.

(*k*) Make of machine:—R & K—Torrence, Weber, Bliss.

9. **Physical requirements:**
   - (*a*) Preferred age: Operator should be about 20 years and not exceeding 30 years when learning punch-press work.
   - (*b*) Preferred weight: Operator should not be too stout, but should be heavy enough to have stamina to withstand the reverberation of the machine and physical activity necessary to turn out a large production.
   - (*c*) Preferred height: Should be tall, about 5 feet, 7 inches, for large presses, No. 3 and No. 4. For other work may be a little shorter.
   - (*d*) Other physical requirements: The operator should have long arms, and full use of hands, arms, and right foot. Good eyesight is very important.
10. **Mental requirements:**
    - (*a*) Preferred nationality: American.
    - (*b*) Temperament: Operator should be of calm, cool temperament, and should be of self-controlled type.
    - (*c*) Experience: Operators to be rated experienced on punch-press work should have had experience in operating punch presses in tin or metal manufacturing plants. If they are learners, it is best to give preference to girls who have had some machine experience, as they will be more likely to overcome the fear of the press and less likely to have accidents.
    - (*d*) Girls must not be of nervous or flighty type.
    - (*e*) Girls who have done housework for any length of time are found to be unsuitable for this kind of work, as the analysis of the labor turnover shows that they will not stay long enough to learn the work and they seem not to have the power of concentration to make good punch-press operators.
    - (*f*) Education, minimum requirements: Able to read and write English and to count.
11. **Learners** are usually taken from sorters or inspectors, as they have a chance to come in contact with machines and get acquainted with the punch-press department.
12. **Method of training**, length of time to learn job: Learners are first placed on machine with instructions to work treadle with foot without feeding any tin for a period of time from 10 to 20 minutes. In this way they become used to the press and will establish the proper co-ordination between the eye and foot. They are usually started on small chute feeding operations or small cutting jobs, such as cutting caps out of scrap, especially work which will not cause the die to become out of order if the operator makes a mistake, and so they slowly pick up the work.

reproduced by the courtesy of a well-known firm which has made notable progress in scientific management.

The many practical uses of standard times and methods, also of job analysis and classification, will be considered more in detail in later manuals, which take up the subject of standardization in general and methods of handling the workers. But before taking up these subjects in detail, let us, in Executive Manual 36, find out how materials and supplies used in production are purchased to best advantage; also how they are stored, cared for, and dispensed for use, as revealed in a study of the organization and operation of the purchasing and stores departments of efficiently managed industrial plants.

First, however, use the following check-up which suggests various uses of principles brought out in this manual. Executive Problem 35, which follows, will, in an interesting way, develop your ability to make a departmental layout which permits the most economical flow of work. This ability, as developed, can be profitably used in any business. Arrangement is always an important factor in efficiency. There is nearly always room for improved arrangement, as you will see in working Executive Problem 35.

CHECK-UP ON PRINCIPLES

Use the following check-up to get the principles of this manual firmly fixed in mind. This will help you to handle the problem which follows. This check-up is entirely for your own personal use, so you need not send it in to the University.

	Check	
	Yes	No
1. Dairy farmers usually locate their silos, in which fodder is stored, near the cows, even tho this location of the silo compels a longer haul from field to silo. Is this a violation of the minimum-travel principle?......		
2. In one large department store each credit man has a stenographer, and her desk is alongside his. In another similar store the stenographers of the credit department remain in a stenographers' room on another floor except when taking dictation. Does this illustrate a conflict between the minimum-travel principle and the principle of departmentization?..................		
3. In a large machine shop the storerooms for tools, jigs, supplies, and many kinds of raw materials and small parts were located in a balcony running the length of the building. Does this location seem to comply with most of the principles you have studied in this manual?		
4. Miners very often carry their lamps on their caps. Does this arrangement illustrate an application of the principles of illumination you studied?.........		
5. In making a time study the work of two expert workmen is observed. A proves to be consistently quicker in setting up the work ready to process, while B is always the quicker of the two in machining the work to exact gauge. The ideal base time was taken as the sum of A's time for the set-up plus B's time for machining. Is this correct practice?......................		
6. It has proved true times without number that an observant and thoughtful newcomer to an office or factory can suggest improvements which the old-timers have overlooked. Does this fact confirm the value of the principle you studied on page 23?................		

	Check	
	Yes	No
7. A typist had formed the habit of twice rapidly depressing and releasing the "cap letter" lever on her typewriter as she started each new paragraph. Is the daily loss in production likely to be noticeable to casual observation?		
8. If a designing engineer sought to improve the efficiency of an automobile as a whole without giving separate consideration to carburetor, engine, transmission, etc., he would be looked upon as a fool. Is it any less foolish to set out to improve the efficiency of a workman's efforts without studying each element of his work?		
9. Does scientific management recognize that the average good workman cannot work at top speed constantly, and does it consequently make adequate allowance for fatigue when setting standard times?.........		
10. Workmen in Extown were hard to get. Mr. A, the employment agent, boasted that he kept his shop supplied notwithstanding the shortage. "If I can't get a molder, I send the shop a fireman or a farmer," he said. "Some of them stick, and the foreman can't complain much so long as I send them husky hands." Is this man following correct principles?................		

Executive Problem 35

A DEPARTMENT LAYOUT

Using the Process Map in Selecting and Arranging the Equipment

UNDER THE LASALLE PROBLEM METHOD

* * *

SMALL daily savings mean big annual profits. An arrangement which saves the work of one $16-per-week boy will pay an 8 per cent cash dividend on over $10,000. Well-selected equipment, properly arranged so that the work will be a minimum and that each worker can do his best, effects savings which may seem rather insignificant. A good layout saves money daily, however, and costs little or nothing. When the books are closed, it may outweigh far more noticeable economies.

Prepared by the Research and Consultation Staff of LaSalle Extension University from an interesting problem which it has carefully investigated and analyzed.

Executive Problem 35

A DEPARTMENT LAYOUT

In this manual you have been introduced to a production problem which is as important in every business office as it is in the factory, for good work cannot be done efficiently anywhere if working conditions are unfavorable, and the equipment poorly planned.

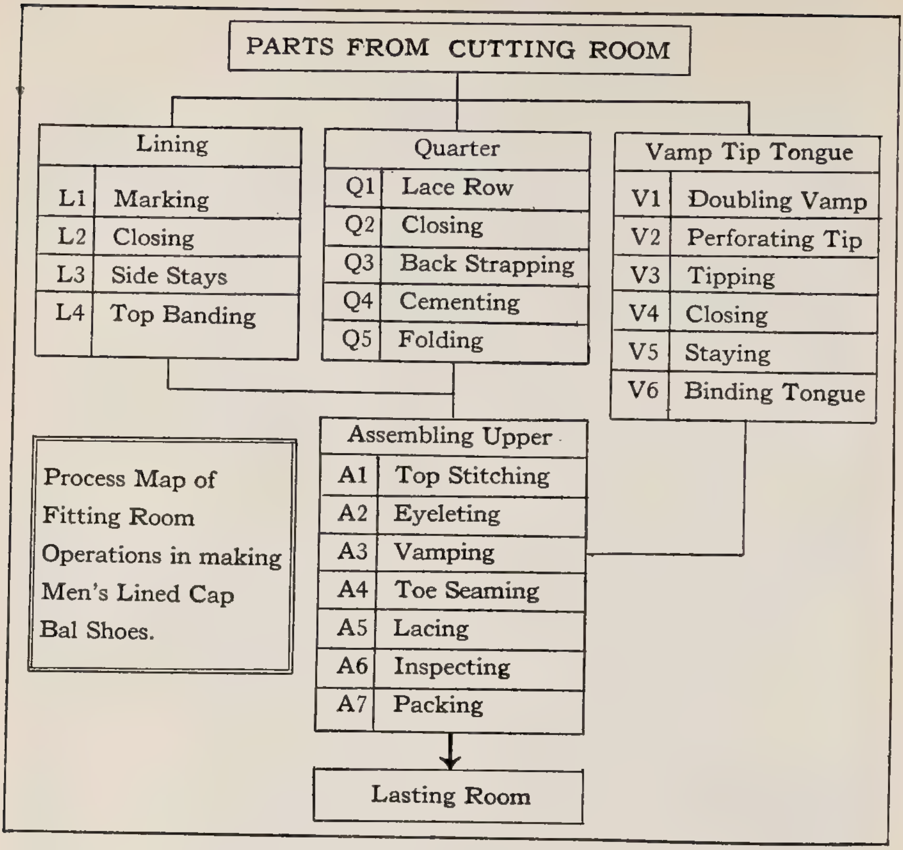
The Two Rivers Shoe Company has been making ladies' shoes for years. Their shoe is of that medium grade which appeals to a very large share of the shoe buying public.

The management has decided to make a line of men's shoes of similar quality which they plan to call the "Gentleman" shoe. It is their plan to make just one quality of shoe of just one general type of construction, tho, of course, the leathers and styles will vary, so as to give their customers a fair range of choice.

Their investigation has shown that shoes can be manufactured efficiently, with balanced production between all operations, in factories designed for a steady output of some 125 cases of shoes per nine-hour day. A case of men's shoes contains 24 pairs, so that the output will be 3,000 pairs of shoes per day—a volume which the sales department believes it can sell right from the first.

This company's experience and that of many other shoe manufacturers have shown that it is necessary to equip a plant for 25 per cent greater capacity than the required capacity, to make allowances for breakdown, absent workers, inexperienced workers, etc. Equipment will, therefore, have to be selected for an output of 156 cases per day.

The plans for the building are complete. It is to be erected several miles distant from the present plant so as to tap a different labor market. A modern building is



now going up on the new site, each floor of which is 50 feet wide by 144 feet long. The long sides of the building are almost all glass so as to provide a maximum of light.

You are an assistant foreman in the present plant and have been detailed to work with a shoe machinery expert in laying out the new plant. This expert has worked with the architect in the design of the building, so it is admirably adapted for its purpose. He has already planned the general flow of work thru the plant and is now planning details for the cutting room, etc.

The Layout of the Fitting Room. He will soon take up the fitting room—the department in which the uppers of a shoe are stitched and assembled ready to be attached to the soles. This department is to have a floor all to itself. Since this department will have women workers almost entirely, and is the only department in the factory that will employ many, the women's rest room and hospital will be put on this floor.

The process map above shows the operations that will have to be performed in this department. You have studied this map, and have been granted this opportunity to use the data of the industrial engineer regarding the equipment needed for these operations, to plan a layout for this department.

Certain principles will be followed. In the first place it has been found in the shoe industry that workers must not sit where their shadows fall on their work. For the operations planned for this department, it does not seem to make much difference whether the light falls from the right or left side or from the front, since the materials are not such as to throw a glare into the operator's eyes, and the machines make little or no shadows.

Fig. 19.

The experience of this company bears out the experience of many others that no operator should be more than 18 feet from a window. It is also shown that a most efficient drive is obtained by having one 1½ H. P. motor for a group of 10 machines. These machines are usually placed on tables about 17 feet 6 inches long by 6 feet wide. This provides five machine positions, each 3 feet 6 inches long, on each side of the table. The motor and shafting which drive this group of machines are underneath the table. Such a table is illustrated in the cut opposite the first page of this problem.

These tables are placed some distance apart, since each operator requires about 3 feet of space back from the table and there must be room for trucks carrying racks on which the work is brought to the workers. The experience of this firm has been that it pays to have ample working room, and tables are, therefore, to be spaced so as to allow a total of about 6 feet back of each operating position. In other words, each table will be given a space of 17 feet 6 inches by 18 feet.

In addition to the necessary tables each one of which has space for 10 operators, there is to be a bench for four inspectors, and there is also to be a drier which, however, takes up little room and need not be considered in laying out the floor space.

A foreman's office must also be provided. It will take up a floor space of 18 feet by 18 feet, which will be railed off from the rest of the space. It should be located so as to interfere as little as possible with the flow of travel and yet be as central as possible so as to give the foreman easy supervision over all the operators.

The working paper contains a drawing of the shoe which it is planned to manufacture and a description of each of the operations that are necessary. It also contains a list of the machines that are required for each operation, and their capacity. From this information you will be able to determine how many machines will be needed, and how much space and equipment must be provided.

The working paper also gives the plan of the floor and of the working space that is left available after provision has been made for rest rooms, elevators, storage space, etc.

As you plan a layout for the department, you will follow the principles of continuous flow and minimum travel, but will be careful to apply these principles so as to give each operator the most effective working conditions.

The procedure that you will follow here may be used in the layout of any production department for any type of work, tho, of course, with some modification. Some of the more important modifications will be explained fully in the executive report.

BUSINESS MANAGEMENT

CONTROL OF MATERIALS

—Being Executive Manual 36, on Principles of Production, in a Complete Plan of Training and Service for Executive Work

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CONTROL OF MATERIALS

Part I

THE PURCHASING DEPARTMENT

TO BUY needed materials of the right quality and at the right price and to secure deliveries of those materials at the right time and in the right quantities are the primary functions of the purchasing department, as previously pointed out in Executive Manual 6, where we made a preliminary survey of the purchasing problem.

How much more may be done in this department depends on the purchasing agent and on the organization of which he is a part.

In some business organizations purchasing plays only a small part, as in a mercantile credit agency or a bank or an insurance office. In most lines of business, however, efficiency in purchasing plays an important part in earning profits. So important is this department in many industrial concerns that the purchasing agent reports directly to the general manager, as shown on the general organization chart on page 14 of Executive Manual 33.

In a large industrial plant, the purchasing agent co-operates closely with the works manager, with the engineering department, and with the treasurer. His many contacts with the outside world permit him to increase the prestige which his company enjoys, and he can bring many new ideas to the attention of his associates in other departments.

The Aims and Qualifications of a Purchasing Agent. One representative purchasing agent stated the objectives of his department as follows:

1. To get the highest possible value received for every dollar expended.

2. To render efficient service to the production department.
3. To maintain his firm's prestige in the business community by building up the good will of all with whom his department came in contact.

He further stated that to accomplish these aims, a purchasing agent must possess the following qualifications:

1. Knowledge of markets.
2. Familiarity with the manufacturing processes of his own company.
3. Ability to establish a relationship of mutual profit with suppliers.
4. Ability to serve the interests of both production and financial departments.
5. Personal integrity and loyalty.

Establishing a Sound Relationship with Suppliers. Of the five qualifications cited, the third and fifth were adequately covered in Executive Manual 6. We should remember the great importance, in both buying and selling, of having a business code based on honor. Now and then a purchasing agent is likely to be offered a more or less thinly disguised bribe. But few modern purchasing agents fail to realize that—

> **A buyer is always expected to pay with interest for each unwarranted favor he receives.**

A purchasing agent who is known to be strictly impartial in his placing of orders, whose decisions are influenced only by the true facts in each case, commands the respect of high-grade suppliers, and his firm will receive the kind of treatment it desires from them.

We should also remember the importance of insuring adequate sources of supply, as brought out in Executive Manual 6. This insurance requires willingness to pay a price which allows a fair profit to suppliers. A purchasing agent who is always shopping around for below-cost bargains from hard-pressed firms will find hard sledding in getting his orders filled in a sellers' market—when there is competition for supplies among buyers.

The farsighted purchasing agent does not buy on price alone, even when he is assured of getting the quality he desires. He is interested in establishing mutually profitable relationships with suppliers.

As was also pointed out in Executive Manual 6, a purchasing agent must have sales ability. Efficient "buymanship" requires ability to "sell" suppliers on giving their best service.

ACTIVITIES OF THE PURCHASING DEPARTMENT

In this manual we shall consider not only the general duties of the purchasing department but more particularly the place which that department fills in the production-control plan.

Let us first outline the main requirements and activities of the purchasing department, as follows:

1. A knowledge of the current and the probable future market and price conditions—passing on to all other departments such parts of this kind of information as may be profitably used by them.
2. Statistical and reference files—as to sources of supply; record of past purchases, prices, quotations; data as to past consumption, probable future needs, etc.
3. The collection of technical data—regarding materials, specifications, tests, etc.
4. Requisition routine—checking requisitions to see that they are specific and that no mistakes are made, and recording and following up requisitions.
5. The actual buying process—obtaining quotations, interviewing salesmen, placing orders, following up deliveries as to time and quality and quantity of goods delivered.
6. Accounting within the purchasing department—listing receipts and checking against orders and requisitions, checking prices, approving invoices, etc.
7. Co-operation with the financial department—advising it of probable cash requirements to meet future invoices, timing the dates and terms of orders placed to fit the company's probable cash on hand, etc.
8. Keeping channels of supply open—as by guarding against placing all orders for an essential material with one sup-

Principles and Standards of Purchasing Practice

ADVOCATED BY

National Association of Purchasing Agents

LOYALTY TO HIS COMPANY
JUSTICE TO THOSE WITH WHOM HE DEALS
FAITH IN HIS PROFESSION

From these principles are derived the N.A.P.A. standards of purchasing practice.

[1] To consider, first, the interests of his company in all transactions and to carry out and believe in its established policies.

[2] To be receptive to competent counsel from his colleagues and to be guided by such counsel without impairing the dignity and responsibility of his office.

[3] To buy without prejudice, seeking to obtain the maximum ultimate value for each dollar of expenditure

[4] To strive consistently for knowledge of the materials and processes of manufacture, and to establish practical methods for the conduct of his office.

[5] To subscribe to and work for honesty and truth in buying and selling, and to denounce all forms and manifestations of commercial bribery

[6] To accord a prompt and courteous reception, so far as conditions will permit, to all who call on a legitimate business mission.

[7] To respect his obligations and to require that obligations to him and to his concern be respected, consistent with good business practice.

[8] To avoid sharp practice.

[9] To counsel and assist fellow purchasing agents in the performance of their duties, whenever occasion permits.

[10] To co-operate with all organizations and individuals engaged in activities designed to enhance the development and standing of purchasing.

WE SUBSCRIBE TO THESE STANDARDS

The high ethical and business principles which the leading purchasing agents have followed for years, have been formulated into a "Creed" and adopted by the National Association of Purchasing Agents as a standard of conduct for the profession. You will find the above chart of principles displayed in many offices.

plier; at the same time guarding against scattering orders among suppliers so that none of them will feel that the purchasing agent is entitled to consideration as a "regular customer."

9. Keeping other departments informed—not only as to changes in price, but also in types or styles of goods that are purchased, as to improved material or devices offered, etc.
10. Co-operating with production by providing deliveries of materials and supplies in accordance with shop needs, and by keeping the production departments advised of any delays, and of shipping dates on material that is specially needed.

In view of the requirements and activities here outlined, it is not surprising that the purchasing agent, in many organizations, is considered to be the most important production official next to the general manager and the works manager. Let us, therefore, further analyze the activities of this department in order to get a workable grasp of this important function in production.

Knowledge of Market Conditions. The purchasing agent is usually a close student of business trends. In Executive Manuals 3 and 4 we saw how changing business conditions tend to change prices. The purchasing agent watches these trends closely in order to know when he should get lower prices and when to anticipate price advances. He will study the general business indices, and will give special attention to the price trends of all the materials and supplies which he is in the market to buy.

Statistics of prices and of production totals as related to demand, as published in current periodicals, may seem dry reading, but their study guides the thoughtful purchasing agent and enables him to understand and anticipate changing conditions.

The successful purchasing agent is a practical economist with an intimate knowledge of the working of the law of supply and demand, as this law applies in bringing about changes in the prices of the things he buys.

A Knowledge of Sources of Supply. There are excellent published lists of suppliers for almost every line of trade; also, the advertisements in trade journals are a helpful source of information, particularly information about new materials and supplies which, if used, would lower producing costs.

But such lists do not give the purchasing agent that intimate acquaintance with the facilities of suppliers, nor that knowledge of the specialties in which they excel, that he needs in order to buy most effectively. This kind of information is accumulated by the wide-awake purchasing agent out of his experience in contact with different suppliers, from interviews with salesmen, from personal inspections of suppliers' plants, and in many other ways. He maintains his own records of information about all suppliers who promise to prove helpful to his firm, filing this information where it is readily available for use.

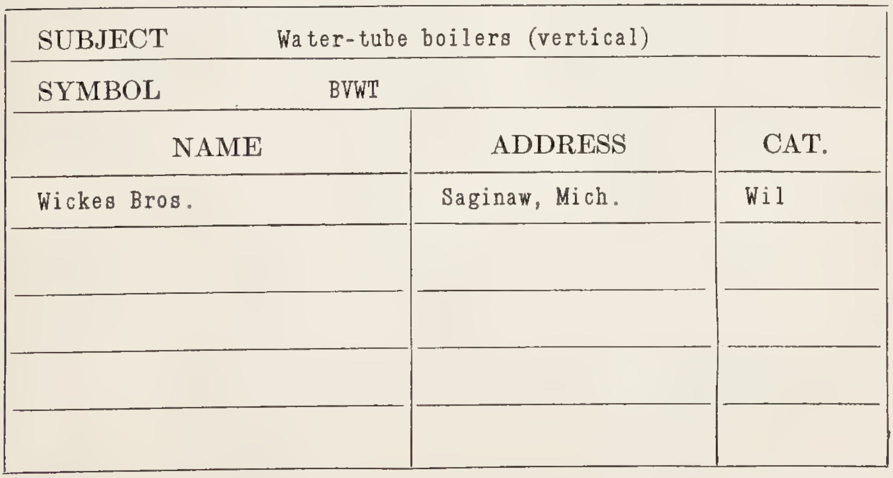
> **Systematic accumulation of facts about suppliers is as important in buying as are accumulated facts about customers in selling.**

The purchasing department should maintain a bureau of information covering the sources of supply of all materials and supplies of the business. These files will include all special information about suppliers as well as their catalogs—all facts that may help in buying, including facts about materials and supplies of all kinds used in the business, as well as facts about sources of supply. They will also include statistical data covering past purchases from each source—the quantities purchased, the prices paid, terms allowed, deliveries, etc.

All this information is best kept in document cases or in filing cases designed to hold catalogs, circulars, leaflets, and sheets. A uniform style of container is advisable.

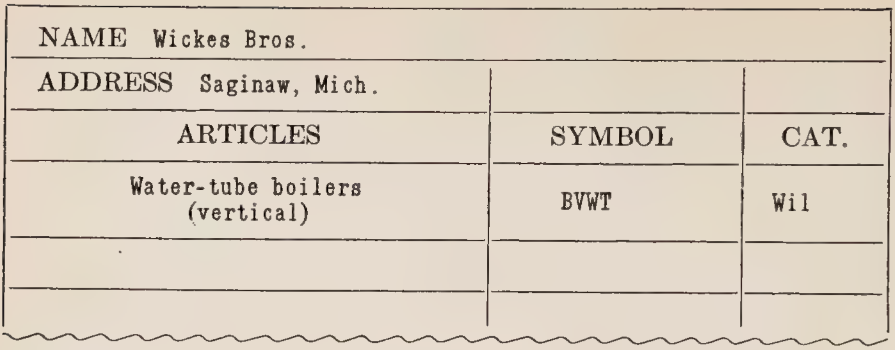
Classifying Buying Information. A mnemonic system of classification, which assists the memory, is recommended. In this system, classes of subjects are designated by abbreviations, which give a hint of the words and are different enough from one another not to be confusing. (As an alternative method a system like the Dewey library system is commended, in which a certain number stands for a certain subject and decimals signify subclassifications.)

As an example of the mnemonic system we might indicate vertical water-tube boilers by the symbol "BVWT" ("Boilers," the general class; "Vertical," the general type; and "Water Tube," the specific type). All catalogs, specifications, data, etc., regarding vertical water-tube boilers would be found in that section of filing boxes marked with the symbol "BVWT," and each individual catalog, circular, or sheet would be marked in the same manner. We must then have two alphabetical finding indexes, one set arranged by names of materials and articles, and the other arranged by names of firms or author, as shown on the two cards illustrated in Figures 1 and 2.



SUBJECT	Water-tube boilers (vertical)	
SYMBOL	BVWT	
NAME	ADDRESS	CAT.
Wickes Bros.	Saginaw, Mich.	Wil

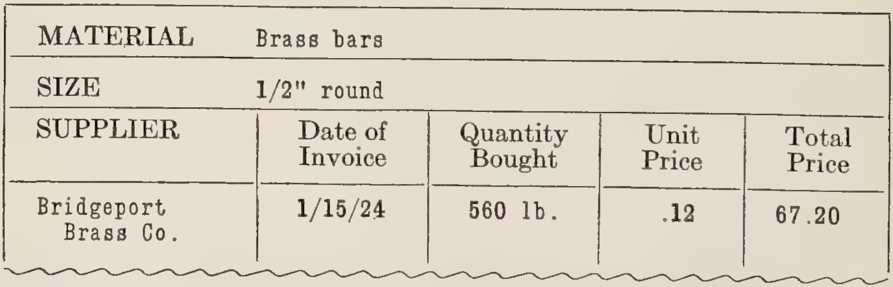
Figure 1. Index for information and catalog file in purchasing department. Knowing the subject, one can locate the catalog, pamphlet, or book by means of this index.



NAME Wickes Bros.		
ADDRESS Saginaw, Mich.		
ARTICLES	SYMBOL	CAT.
Water-tube boilers (vertical)	BVWT	Wil

Figure 2. Index by names of firms or authors for purchasing department's information and catalog file. Knowing the name of the firm or author, one can locate the catalog, pamphlet, or books by referring to this index.

The method of filing above summarized is much better than the method, frequently used, in which catalogs are filed either by sizes or as they are received, and are numbered consecutively. It is true that the index cards under this system will locate the catalogs and pamphlets, but the method illustrated in Figures 1 and 2 has the advantage of automatically bringing together everything bearing on a given subject. The mnemonic system and the Dewey decimal system are flexible; the space allotted to any subject may be enlarged as the number of catalogs or papers on that subject increases. The tests of an efficient filing system are flexibility, expansibility, and, most important, ease in finding the desired information.



MATERIAL	Brass bars			
SIZE	1/2" round			
SUPPLIER	Date of Invoice	Quantity Bought	Unit Price	Total Price
Bridgeport Brass Co.	1/15/24	560 lb.	.12	67.20

Figure 3. Materials-purchased record, used as a statistical basis for estimating quantities of materials and supplies consumed in a given period of time, and showing also the past cost.

Records of Former Purchases. Records of past purchases are valuable statistical data on which to base estimates of future requirements and costs; also decisions on sources of supply. Such records should be classified by materials, and should show sources, quantity, and prices. Figure 3 shows a materials-purchased record, indexed by materials and with a separate card for each size of material. These records are filled out from current invoices, as they are received, by a clerk in the purchasing department who is responsible for keeping up the record.

A Record of Quotations. It is desirable to have a record of quotations as well as a record of materials purchased.

The reasons for keeping a quotations record are—

1. It gives in compact form the names of firms that have made quotations in the past and from whom quotations can be secured again.
2. It shows what competitive prices were secured.

The quotation record may be kept on cards or on loose leaves similar to the record of materials purchased, shown in Figure 3, the only difference being that usually not so many sizes and styles of material need be classified as in the record of actual purchases.

Knowledge of Materials. Altho the purchasing agent cannot be expected to know the technology of a business with all the scientific accuracy that characterizes the technical knowledge of the chief chemist, the chief engineer, or the designers, he must have or acquire such a knowledge of the industry and its processes that he can pass intelligently on all buying questions relating to the materials and supplies he is called on to buy.

The engineering department—or the proper technical department, whatever it is—should furnish the purchasing department standard specifications for all materials used in production. These specifications become part of the records in the purchasing department files.

The purchasing agent should also receive results of all inspection and laboratory tests of materials for his information and guidance. He must know also how these materials are to be used. The suppliers' salesmen can usually contribute ideas regarding new uses and new methods. A purchasing agent who understands his firm's problems can pick up and pass on much helpful information about materials.

Requisition Routine. The purchasing department does not, as a rule, buy things on its own initiative. It is true that the purchasing agent will often take the initiative in suggesting that prices or other conditions make it desirable to anticipate the company's needs for materials. In some cases the purchasing agent is even given authority to make such purchases without O.K.'s from higher officials. But, in general, the purchasing department buys only after it has received an approved requisition.

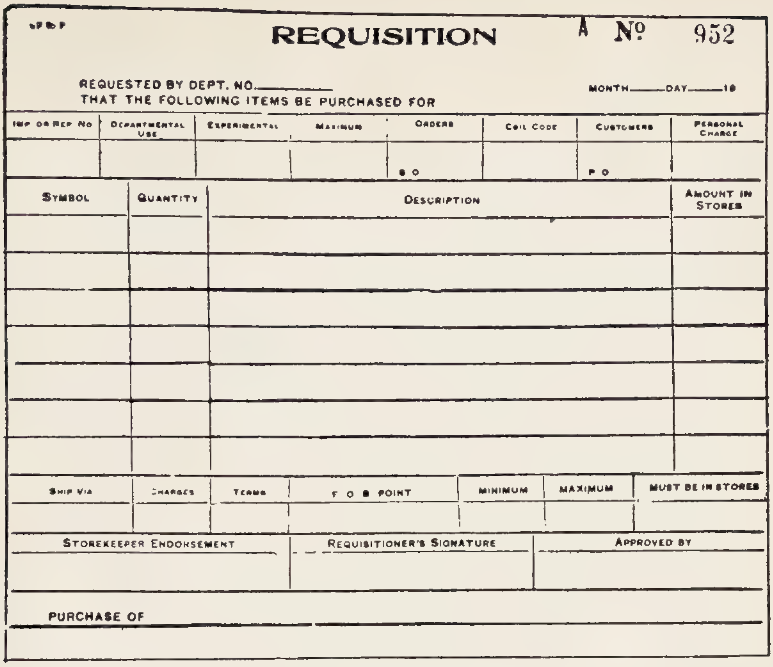
General management usually designates a list of department heads who are authorized to make requisitions on the purchasing department.

In many organizations most requisitions come from the stores-department head, who is responsible for maintaining a stock of all materials and supplies needed. Such requisitions should bear the signature of the department head and be countersigned by either the works manager or the office manager to show that he has approved them.

Requisitions usually state definitely what is wanted. It is customary, however, not only to allow the purchasing manager to suggest changes in requisitions, but also to encourage him to do so. Such suggestions lead to a mutual understanding, which cannot be gained if the purchasing agent is compelled to buy, without questions, exactly what is specified. But—

> **There should never be any departure from the specifications of the requisition when it has once been finally approved.**

In each department certain men are authorized to write requisitions. Such requisitions should be on a standard form, of which a sample is shown as Figure 4.



REQUISITION A № 952

REQUESTED BY DEPT. NO.________
THAT THE FOLLOWING ITEMS BE PURCHASED FOR

MONTH____DAY____19

Imp or Rep No	Departmental Use	Experimental	Maximum	Orders	Coil Code	Customers	Personal Charge
				S O		P O	

Symbol	Quantity	Description	Amount in Stores

Ship Via	Charges	Terms	F O B Point	Minimum	Maximum	Must be in Stores

Storekeeper Endorsement	Requisitioner's Signature	Approved by

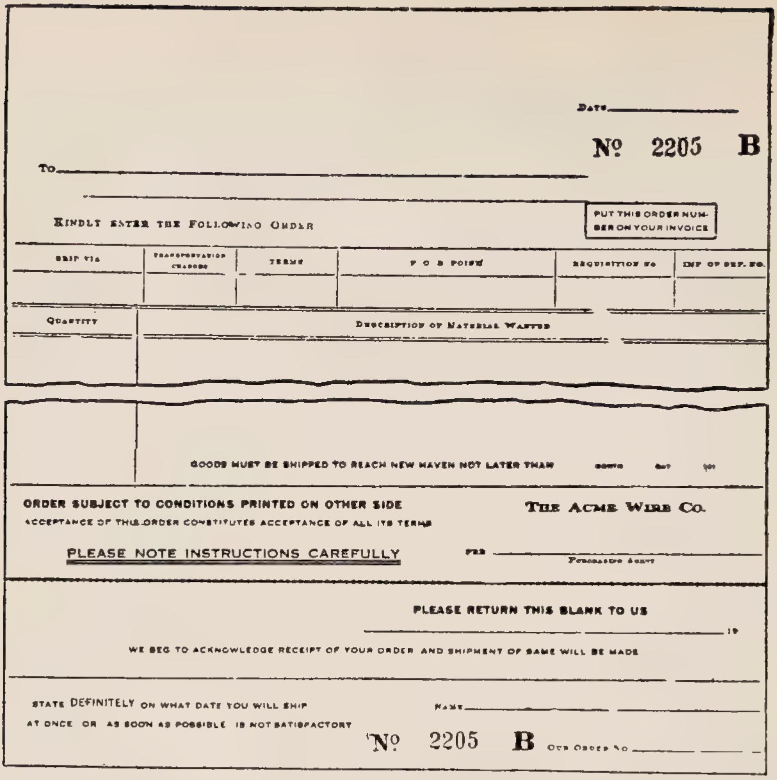
PURCHASE OF

Figure 4. A typical requisition form.

This requisition is usually signed by the department head, and often it must be O.K.'d in the engineering department; also in many cases it must be passed upon by the works manager, or the office manager, or the general manager before it goes to the purchasing department for buying action.

Purchase Orders. In some lines of business the requisition is written out in manifold copies, and one copy is used as the purchasing agent's order to the supplier. This, however, is unusual practice. Usually, after the purchasing department has decided where to buy the goods, a purchase order is made out which describes the goods very definitely, as shown in Figure 5. The original of this purchase order is sent to the suppliers, while several duplicate copies are filed for reference.

One method of filing copies of the purchase order is by the departments from which the requisitions emanate. It is customary to file both the requisitions and the cor-



Date ____________

№ 2205 B

To ____________

Kindly enter the Following Order

PUT THIS ORDER NUMBER ON YOUR INVOICE

Ship Via	Transportation Charges	Terms	F. O. B. Point	Requisition No.	[illegible] No.

Quantity	Description of Material Wanted

GOODS MUST BE SHIPPED TO REACH NEW HAVEN NOT LATER THAN Month Day Year

ORDER SUBJECT TO CONDITIONS PRINTED ON OTHER SIDE
ACCEPTANCE OF THIS ORDER CONSTITUTES ACCEPTANCE OF ALL ITS TERMS

PLEASE NOTE INSTRUCTIONS CAREFULLY

The Acme Wire Co.
Per ____________
Purchasing Agent

PLEASE RETURN THIS BLANK TO US

____________ 19

WE BEG TO ACKNOWLEDGE RECEIPT OF YOUR ORDER AND SHIPMENT OF SAME WILL BE MADE

STATE DEFINITELY ON WHAT DATE YOU WILL SHIP
AT ONCE OR AS SOON AS POSSIBLE IS NOT SATISFACTORY

Name ____________

№ 2205 B Our Order No ____________

Figure 5. A typical purchase order. This form is prepared in quadruplicate.

responding purchase orders, according to the departments from which they emanate, in one "jacket," keeping them together for convenient reference.

The purchasing department should also have a reference index or finding list for purchase orders. This index is arranged—

1. By names of firms to whom the orders were sent.
2. By purchase-order number.

Thus there is ready reference to the outstanding orders which each supplier has not yet filled, and a purchase order can be readily located when its number is given. Such a "cross-reference" index can be written up in a loose-leaf index or on a card index, or the same purpose is fulfilled by filing an extra carbon copy of the purchase order alphabetically by name of supplier, and another in numerical order.

Following Up Purchase Orders. An important function of the purchasing department is performed by the use of a "tickler file."

To get the goods at the right time is one of the most important functions of the purchasing department. In purchasing materials and supplies of many kinds, it is necessary to remember that—

> **Delay in deliveries may have a far more serious effect in the way of increasing costs of production than would the payment of higher prices for prompt deliveries.**

A tickler file may have a compartment for each day, or it may be of the visible-index type. A copy of the purchase order is filed in this tickler, to be drawn out on the day when promise of shipment or notice of shipment should have been received.

If a definite promise or a notice of shipment has not then been received, a follow-up letter may be written, or a telephone inquiry made, and the papers are again filed under a new date in the tickler file, to come up for attention at the new date.

In case the first formal follow-up letter or card does not bring a prompt reply, the next follow-up letter or telegram, in a series of carefully worded form letters and telegrams, can be sent. This series of follow-ups usually ends in a cancellation of the order (provided goods can be obtained elsewhere), as a penalty for the supplier's failure to live up to his agreements as to delivery. Follow-up correspondence of this kind can also, of course, be written individually, but usually expense is saved by using carefully prepared form letters. How to write effective letters of all kinds is explained in a later section of this training service. The records of various suppliers in keeping their promises of delivery are important items in the purchasing department's information files.

THE ART OF BUYING

The routine of buying, just described, took us to the issuing of the purchase order. But before the order is placed with a supplier, an agreement must be reached with that supplier to furnish the specified goods at a stated price and within a definite time limit. Agreements of this kind call into play the art of buying, which art is as important to the buyer as the art of salesmanship is to the salesman.

The main test of the value of a purchasing agent to his firm is his efficiency in the art of buying advantageously.

As a rule, the purchasing department's experience and its information files narrow down the choice of suppliers to a comparatively small number for each class of goods purchased. These few suppliers are usually asked to send in competitive bids.

Price, delivery, possible delays, and the general standing of the bidders are then considered before a decision is reached.

That simple procedure sounds far easier than it is. Qualities and type of goods vary. All have their special talking points—and enthusiastic salesmen make the most of those points of excellence. Also, a salesman is constantly tempted to promise deliveries which will be difficult to make. Furthermore, the asking price of some of the prospective suppliers is not always the lowest bid they will make for the order.

A purchasing agent, like a salesman, must be a student of human nature. He must be able to gain the confidence of salesmen and to get their good will toward him and his firm. His is the task of picking out the best of competing suppliers on the basis of what they actually can and will do for his firm, and he must not let the personality of a salesman influence him unduly, either favorably or unfavorably; for the salesman with the poorest personality may represent a supplier who can and will give most and do most for the money.

It is customary among purchasing agents to consider all quotations as confidential information, and it is bad practice to try to get a supplier to cut the price at which he bids for the order, on the ground that another supplier's price is below his, perhaps naming the other supplier. Suppliers and their salesmen soon find out when buyers do not treat their bids confidentially, and it is difficult for those buyers to get satisfactory bids, especially when goods are scarce.

The purchasing agent must know exactly when the materials will be required by the shop. This will assist him very much in negotiating with the suppliers, for oftentimes he can make more favorable arrangements when the supplier is permitted to ship on dates which suit his convenience, yet are early enough to meet the shop's needs.

Two Buying Policies. There are two distinct policies observed in the matter of delegating responsibility to the purchasing agent. One is to limit the purchasing agent to the buying of materials at such times and in such quantities as requisitions from store and operating departments may specify. The other policy encourages the purchasing agent to study the market conditions and to recommend purchases at times when prices are low.

Those who favor the first policy contend that to buy in accordance with market conditions is to place the purchasing function in the field of speculation, where, they say, it does not belong.

Where production is variable and it is difficult to determine the requirements in advance even approximately, the nonspeculative policy is necessary. But where records of former purchases, the data regarding orders in hand, and the probable production of the next six months or a year form a reliable basis for a fairly accurate estimate of the materials required for this period, the second policy of buying when the market is low is frequently adopted.

This speculative policy, when it involves outright purchase in advance of requirements, means that sufficient funds must be available, in the form of cash on hand or borrowing capacity, to pay for the larger stocks of materials and for carrying the stock in storage. Larger storage space is required, but is used to capacity only part of the time.

Contract Buying. To contract at one time for future deliveries of materials or supplies at prices agreed upon in advance is common practice in some lines.

In buying copper wire, copper and brass bar stock, steel and iron shapes and angles, and sheet steel, contracts can be made calling for the delivery of a certain weight or tonnage of materials of certain specifications within a specified time at a price which is specified as so many cents a pound (or dollars a ton) above the current "base" price of the raw materials at the date when shipment is to be made. Thus the price changes with fluctuations in the raw-material market, but the manufacturing service of the supplier is purchased at a fixed price. The buyer may, in turn, raise or lower his own prices to cover changes in the market value of the raw material his product contains.

Under another form of contract, running usually for a shorter time, the supplier may agree to furnish the goods at a specified unit price, the seller assuming the risk of a rise in the market price, and the buyer assuming the risk of a fall.

Co-operation of Purchasing and Financing. Every purchase order sent out means, in the near future, an invoice covering goods received, which must be paid; therefore, the necessity of close co-operation between purchasing and financing.

Usually requisitions which call for purchases above a certain amount must be approved by the financial executive of the company. On every purchase which commits his company to large future payments, the purchasing agent, in nearly all cases, will consult the treasurer of the company. He knows how important in buying advantageously is his firm's reputation for promptly meeting financial obligations.

> **In every practical way, a wide-awake purchasing agent seeks to build up good will toward his company on the part of suppliers, so that he can buy from them more advantageously.**

In nearly all cases the purchasing agent sends the treasurer's department a copy of all purchase orders with the exact amount to be paid noted thereon (or as close an estimate as possible), so that the treasurer may be advised in advance about all incoming invoices and be prepared to take care of payments promptly, taking the fullest advantage of cash discounts.

The purchasing agent is also often made responsible for checking the invoices received to insure that the prices and terms are those agreed upon, and is also often made responsible for checking the invoices with the receiving department records to insure that all goods have actually been delivered.

Insuring Constant Sources of Supply. On his way home from his office, a purchasing agent was delayed by a fire that completely destroyed a large building. His firm had no direct interest in this fire, but he asked himself, "What if that fire were to spread to a near-by foundry where we have for years been buying those intricate castings which would be very difficult to buy elsewhere?"

That question led him forthwith to have duplicate patterns and core boxes made, and to find another foundry that would also become expert in making these difficult castings.

It is advisable to guard against all hazards that may cut off the supply of important materials and parts.

A purchasing agent in a small company required certain spun-brass parts, which were supplied by a large producer on a yearly contract at a fair average price. In years of business depression this purchasing agent was besieged by salesmen from small manufacturers who offered low prices for an order, prices below the contract price of the large producer. But in years of depression, as well as in more prosperous years, the large producer got this contract, because this purchasing agent applied an important principle of efficient purchasing. He considered certainty of supply more important than temporary price advantages. Let us remember that in buying materials and parts of many kinds—

Absolutely dependable sources of supplies must be counted as assets that are above temporary savings.

Other Responsibilities of the Purchasing Department. A purchasing agent, with his door open to salesmen and his eye open to advertisements—both being good sources of information about new goods and new methods—is greatly remiss unless all the new ideas that appear feasible are brought to the attention of his associates in the shop, in the engineer's office, and in the general office. That is naturally a responsibility of the purchasing department.

In addition to the more direct purchasing responsibilities explained in preceding pages, control of certain related activities are sometimes placed in this department, such as—

1. Receiving.
2. Stores.
3. Traffic.
4. Inspection.

In commercial businesses, receiving and stores are activities often placed in the purchasing department. In industrial plants, however, it is more usual to place them under the works manager.

Where incoming shipments are the largest part of a company's traffic, it may be advisable to place the traffic responsibility in the purchasing department. But in most cases, particularly where outgoing as well as incoming shipments are large, traffic management is best placed in a traffic department, having the traffic manager report directly to the general manager.

Inspection, especially in industrial plants, is usually much more than checking up the quality of incoming material, and this function of management is usually placed under the works manager, especially so in cases where the receiving and stores departments are under the works manager.

Developing Understudies. A special responsibility of the purchasing agent is that of developing understudies. While the principle of developing understudies is important in every department, it is particularly important in this department, because a purchasing agent has to conduct many personal or telephone negotiations which cannot be interrupted. Also, his duties not infrequently take him out of his office. During such times, many other important matters are coming up for immediate decision and action. Hence it is important that the purchasing agent train and develop understudies who can take his place in handling any important matters which may arise.

Purchasing a Factor in All Business. When industrial plants started to make a scientific investigation of their purchasing problems, they studied the policies and methods of commercial buyers, because they knew that many commercial successes were the result primarily of the buying skill of their founders. Buying skill is yet found to be more highly developed in commercial than in industrial organizations, because in the retail store, for example, success depends as much upon efficient buying as upon efficient selling. It may be said, in fact, that—

> **A merchant cannot profitably sell the right goods at the right prices unless he has first bought the right goods at the right price.**

However, managers of commercial enterprises are now finding it profitable to study the scientific methods employed by industrial purchasing agents. Retail or wholesale merchandise managers realize, with new force, the importance of some of the older buying principles when they see them applied by modern purchasing agents in industrial concerns.

Every business has a buying as well as a selling problem. Every individual worker has buying and selling problems of a personal nature. The opportunity for applying sound principles which underlie successful buying is a broad one and is open to all. Every business and every person should strive to be a better buyer. Better buying implies better selling—and it compels better selling.

While more attention is ordinarily paid to selling than to buying, let us not forget that buying, as well as selling, has a direct influence on net profits.

There is another side to the control of materials, technically called "stores." The larger and many of the smaller industrial plants have well-organized stores departments which have the special responsibility of providing space and security for materials and supplies purchased and for partly finished and finished parts that are held temporarily before being again put into work. In Part II we shall analyze the functions and methods of a well-organized stores department. The principles that govern the efficient handling of stores in manufacturing concerns, as brought out in Part II, are broadly applicable in every line of business.

CONTROL OF MATERIALS

Part II

The Stores Department

LUMBER is money. Silk is money. Castings are money. All materials are money; that is, they represent the working capital tied up in them. Having more lumber or silk or castings on hand than is needed means that more money is tied up in them than is necessary, which is a drain on working capital.

Financial Importance of Materials. In many other ways material is as important as is cash. Silk or any other material that has been allowed to spoil causes as actual a money loss as an uncollectible account, and the pilfering of expensive parts for the junk brass they contain is no less serious than making away with the pay-roll funds.

High-grade men are employed to care for and keep accurate records of the company's cash, yet the same company's materials, supplies, finished parts, and finished product, which may represent from fifty to one hundred times as much money as the company's cash on hand and in bank, are often left to the care of inadequate and careless help.

Stores represent money. A cashier's office, manned by help who could not tell the difference between good and bad money, whose cash drawer did not balance with the petty cash account, and who could not account for receipts and disbursements, would not be tolerated; yet many large industrial establishments put men in charge of their materials who handle the stock in just such an inefficient manner.

> **Goods, whether raw materials, partly finished, or ready to ship, are, if in perfect condition and up to date, as truly quick assets as are cash and accounts receivable, and require as faithful and intelligent handling, supervision, and safekeeping.**

Thus the executive in charge of stores is responsible for the safekeeping of all goods stored. He will also watch stocks of materials and supplies to insure as rapid a rate of turnover of the working capital they represent as is consistent with maintaining a supply of material which is adequate for all needs.

Maintaining Adequate Stocks of Materials. The old saying that "time is money" applies with special force in a manufacturing plant. Nowhere else can delay cause more serious direct and indirect losses.

The failure to have certain special metal castings may delay the completion of a turbo-generator governor, and that may, in turn, delay the completion of a larger power plant, which may involve the loss of a very large amount of money. Again, if, just when the shop is busiest, the supply of rivets runs out, much idleness may result in the plant while the purchasing agent and works manager are frantically searching for a sufficient local supply to continue production. Not only do costs pile up, but also the morale of the workers suffers. All because the storekeeper suddenly and unexpectedly finds that rivets are all out of stock.

Management of stores guards against such losses by "stocking up" on all needed materials in advance, using a system of stock keeping which automatically maintains a certain safe minimum of stock on hand.

Materials and supplies for any production program can almost always be accurately determined in advance, and there is in nearly all cases no good excuse for being short of needed stock. Management of stores recognizes the fact that—

> **Having sufficient material constantly on hand to meet current needs is necessary to reduce idle time of plant and men—one of the greatest sources of loss in industry.**

It is apparent that the responsibilities of the stores department, as a factor in attaining low-cost production, are of great importance. Let us, therefore, consider carefully the organization and the routine of this department, with a view toward gaining a practical understanding of how these responsibilities are successfully handled.

We shall also see the facilities with which this department must be provided in order to do its work effectively; and we shall gain a more complete understanding of the responsibilities of this department, including its responsibility in serving other departments, and how its records serve in adjusting insurance losses; in short, we shall find out how production management functions in its control of materials.

What Is Control? Let us first make sure that we understand the full meaning of the word "control" as used by the industrial engineer. Consider the following definition:

> **Control is the process by which an executive keeps in touch with, supervises, and directs the conditions and activities for which he is responsible and the procedure thru which he puts his plans and policies into effect.**

Let us study that definition carefully, because the word "control" is used in business in many different connections, and we should be sure to understand its real meaning.

Accountants often use this word. They speak of inventory control, accounts-receivable control, etc., and they mean the processes by which a responsible executive keeps in touch with the present condition of the inventory, of the accounts receivable, etc. With this knowledge as a guide, the executive then directs the work for which he is responsible and establishes the procedures thru which he puts his plans and policies into effect. All this is included in the idea of control, as here defined. Note also some things which are not, by themselves, control.

Control is not a system of bookkeeping, nor of shop or office routine, altho such systems serve as a basis for effective executive control.

Control is not a series of more or less arbitrary commands based on snap judgments. But control always has in it the element of authority which enforces decisions and carries out plans.

Control is not a code of laws, nor of rules and regulations, tho it is true that a series of standardized procedures almost always define the methods by which the control process operates.

Control does not mean a lot of data or statistics that are too old to be useful in detecting troubles before they result in serious losses; but it does provide the executive with condensed facts and figures concerning current conditions which are useful in reporting trouble before it results in serious losses.

What Is Material Control? Let us now apply our definition of control to the stores department.

Material control is the process by which a responsible executive (the general manager, the works manager, or the production manager), thru responsible subordinates, and by means of a carefully planned system which is conscientiously carried out, keeps constantly in touch with the amount of all materials on hand and their condition, the amounts which will be required over a definite period of time, the amounts that have been ordered and the time when they will arrive, and the costs of all materials.

And that is not all. Materials control also includes supervision over all the materials, over the facilities for handling and storing them, over the men who do this work, and over the methods which they follow and the policies they carry out.

Materials control also means an intelligent use of all the information and facilities just mentioned in carrying out two basic ideas emphasized in preceding pages:

1. That stores represent money.
2. That production must not be delayed for lack of materials or supplies

Now, if the meaning of control is not entirely clear, study again the meaning of this important term. It is very important. In fact, the work of every executive may be grouped under two heads:

1. Development.
2. Control.

Let us here note the fact that—

> **It is thru control of materials, of planning, of labor, and of overhead that production management gauges and directs the attainment of low-cost production of the correct quantity and quality of products.**

By control thru costs, a subject to be taken up in Executive Manuals 37 and 38, management gains a dollars-and-cents control thru which its success in exercising the more specific controls just mentioned can be measured.

LOCATION AND EQUIPMENT OF STORES DEPARTMENT

We are now ready to take up our analysis of materials control, including, first, the location and equipment of the stores department; then we shall consider the handling of materials; systems used in storing, recording, accounting for, and handling materials; perpetual inventories; etc. We shall gain a practical understanding of materials control in detail, and this will be an important part of our training for executive work, because the proper control of materials and supplies is an important executive problem in nearly all business concerns. We can best learn how to handle this problem efficiently by studying it as handled in a large industrial plant where it is a problem of relatively great importance and is made the responsibility of a separate department.

The Location of the Storerooms. While the records of the stores department may all be kept in one place, stores of materials and supplies may have to be distributed in various rooms or buildings to be conveniently located for the efficient handling of materials. If this is the case, each separate storeroom will require certain clerical and manual labor, but all the storerooms will be under the supervision of the general head of the stores department.

Stores of castings are often best located near the first machining processes; bar stock for forging, near the forge shop; while finished machined parts may best be stored midway between the machine tools and the assembling and erecting departments. Finished products are almost always stored adjacent to the shipping department.

In Executive Manual 35, where we studied plant layout, we saw how important is the principle of minimum travel of materials. Application of this principle in many cases requires the use of several separate storerooms. But it is well to remember that—

> **The stores department can be most efficiently administered if all the goods, and the help needed in handling them, are, so far as practical, centered into one storage room or a series of rooms grouped close together.**

The layout shown in Figure 5 on page 19 of Executive Manual 35 illustrates an effective compromise between separated and centralized storerooms. There the storerooms for raw materials and supplies are located alongside of each other, and the parts and the subassembly storerooms are similarly grouped, without, however, interfering with the natural flow of manufacturing.

An effective plan, often used, is to put the storerooms on the dark side or in the center of each floor in a multifloor building, and close to the freight elevators. So located, the storerooms, especially when located in the center of each floor, are likely to be conveniently located;

and they occupy the less valuable, poorly lighted manufacturing space.

The Storeroom Equipment. Careful attention must be given to the shape, size, and equipment of storerooms and store buildings in an industrial plant. Overcrowding should be avoided. There must be room for trucks to pass thru the aisles. There must be room for expansion, and often bins and racks must be specially designed for particular purposes.

A pneumatic-tube system between all the departments concerned with material records, or some other inexpensive and fast means of delivering the records, is desirable. It permits a more continuous and prompt accounting system than does the slower factory mail-delivery system. Dumb-waiters to various floors and cable-driven baskets for conveying light goods are often used to great advantage.

Altho it is not necessary to have good natural light in storerooms, as previously suggested, yet adequate lighting should be provided for all working spaces.

The storeroom fixtures—shelving, bins, racks, bin fillers, drawers, and the like—should all be carefully designed or selected to fit the needs as determined by the shape, size, quantities, necessity of protection against deterioration, etc., of the goods to be stored, applying the following principle:

> **Fixtures should be designed to store a maximum amount of goods for each foot of floor space and at the same time give easy access to the goods.**

Application of this principle underlies the use of many fixtures that are "tailor made" for their purposes. But in nearly all cases, we cannot be so certain of future developments as to justify us in overlooking another principle, application of which may modify our application of the foregoing principle. It may be called the principle of expansibility and interchangeability.

Buildings and fixtures should be laid out and built with a view to possible expansion and possible change in use.

The makers of metal shelving and racks have given much study to the design of storeroom equipment which will store a maximum of goods in a minimum of space, and which can also be readily adapted for new uses. Their catalogs give many valuable ideas along these lines.

Each drawer, bin, or section of rack is usually provided with some device to hold a tag or card which bears the name and symbol of the article stored in it, and often space is provided on the tag or card for a record of additions to and withdrawals from the stock.

Stores and Material Handling. There are many opportunities to effect a saving in labor and other economies in handling the materials as they come from the receiving department, as they are put into the storeroom, and as they are later taken from storage and delivered to the various departments.

Trucks of various kinds, industrial railways, conveyor belts, hoists, cranes, and the like often prove to be very profitable investments even in many cases where mechanical conveying and lifting equipment is not absolutely necessary.

The problem of handling materials is so closely related to the general problems of stores management that in most cases it is assigned to the stores department, altho sometimes a "move-materials man" is appointed to be in charge of all interdepartmental movements of material, and the various truckers all work under his control.

How Material-Control Systems Vary. In a continuous-process industry of the analytic (taking apart) type, such as in a flour mill or a meat-packing plant, it is a comparatively simple matter to provide sufficient storage capacity to avoid a shutdown from lack of raw materials and supplies and to arrange for a steady flow of materials and supplies to correspond to the output, once the capacity of the plant has been determined.

In a synthetic (putting together) industry, of an assembling nature, the problem of providing the materials in proper quantity at the right times and places is more complex. But where the finished product is composed of a narrow range of styles or sizes of a standard product, such as typewriters or sewing machines, the requirements can be fairly well anticipated for a considerable future period.

Where, however, the products are made up after they have been ordered, as in the case of many kinds of machinery, only a portion of the parts are made up in quantity for stock, and work on the larger and more expensive parts in particular is not started until sales are made. The problem of stores control then becomes still more involved.

In assembling a standardized product for stock, the executive who is responsible for stores is usually responsible only for safeguarding the raw materials and parts that are in his charge, while the responsibility for ordering raw materials and for manufacturing all needed parts rests on the general manager and the works manager. In manufacturing to fill orders, however, the responsibility for having parts and materials on hand, ready to make up customers' orders, is usually placed on the stores-record clerk or storekeeper.

Let us now consider the system of stores accounting employed in a stores department where the responsibilities are relatively broad.

STORES ACCOUNTING

An efficient system of stores accounting provides the means of answering the following questions:

1. What materials have been bought?
2. On whose authority were they bought?
3. What unfilled orders for materials are outstanding?

4. What materials have been disbursed?
5. To what person, order, or account have all materials disbursed been charged?
6. What materials are required for present and future production orders?
7. What quantity of each kind of material is actually on hand?
8. What is the balance (or shortage) with regard to each item after deducting reserve for orders on hand.

Moreover, the unit price must be known for every item so that a money value can be determined. There is great value in using correct methods of stores accounting which answer the foregoing questions.

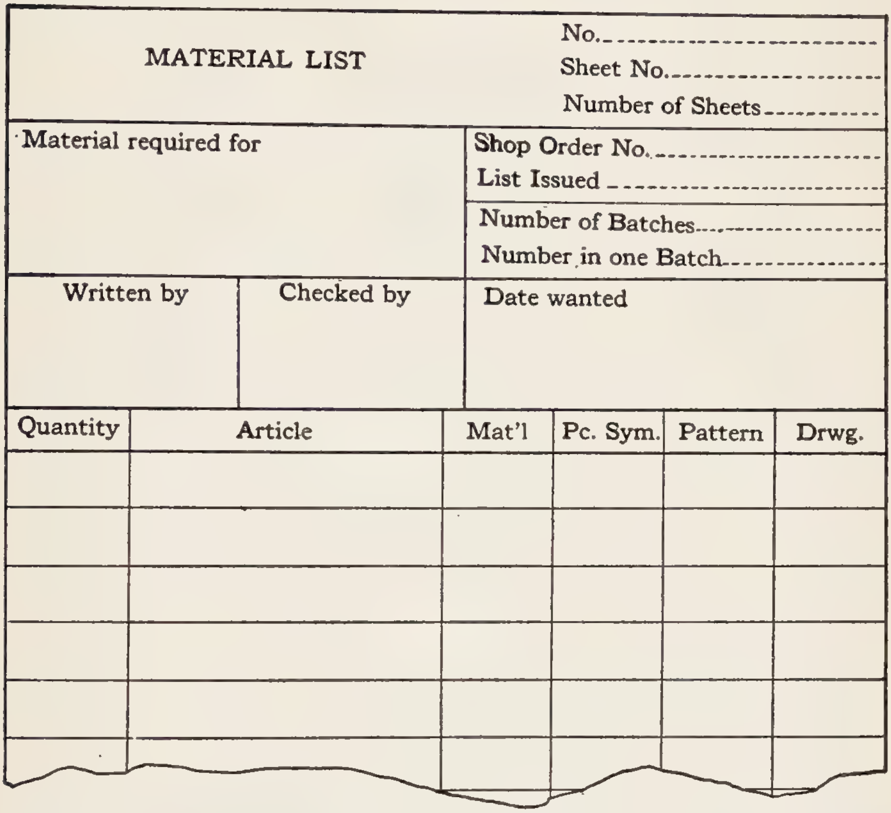
An automobile manufacturer placed his orders well ahead of his needs for all the parts he bought. The firm that supplied the carburetors delivered hardly half the number of carburetors contracted for, and the stores-control system used by this automobile manufacturer was so faulty that the shortage was not discovered until the stock of carburetors was exhausted—right in the midst of the busiest season. It took this manufacturer more than a year to regain the ground he lost by his inability to make deliveries while waiting for carburetors.

> **The concern that lacks an efficient plan of accounting for materials thereby risks incurring serious losses.**

Specifying the Materials. The basis on which all materials required for production are ordered is a bill of materials as determined by the design of the product. This bill of materials is therefore usually prepared in the designing engineer's office. It is a complete list of all the individual component pieces which, when properly put together, constitute the finished product.

Material lists, based on the bill of materials, are prepared for each production order, showing the parts that are required on it. No matter what the class of manufacturing, complete and detailed material lists should be prepared by a person, or department, who is well qualified for this work and to whom all production orders should go.

Omissions are likely to be found in a bill of materials and in material lists when the production is under way. Bills of materials should be carefully checked for omissions and should be corrected before being used again as the basis for orders.



MATERIAL LIST

No._______________________

Sheet No.____________________

Number of Sheets___________

Material required for

Shop Order No.____________________

List Issued _________________________

Number of Batches__________________

Number in one Batch_______________

Written by

Checked by

Date wanted

Quantity	Article	Mat'l	Pc. Sym.	Pattern	Drwg.

Figure 6. A material list on which are listed all the material and parts needed to manufacture one or more assembled parts or complete machines.

Figure 6 shows the form of a material list used in a concern that builds machinery and keeps an accurate account of materials. A number is used to identify the material list so that, if the product is standardized, the list can be used again, and may serve for reference in ordering repair parts. The number of the order for which this list of materials is used is given, and the date on which the sheets are issued is shown; also the number of sheets issued in this material list.

Then follows the list of separate material items that will be required, giving the quantity of each, the name, the material of which it is made, the symbol, the pattern number, the drawing number covering each individual piece. The material list is signed by the responsible official or department head after it has been checked against the bill of materials, and in some cases against the design.

This latter checking is important where changes in design are sometimes desirable. For instance, it may be planned to replace a bronze fitting by a malleable-iron fitting, or a wrought-iron piece by a steel piece, yet the change may not be known to the order clerk when the material list for a new order is being prepared. Checking at this point—before the material list goes to the order clerk—frequently prevents changes while the work is in process, and thus prevents waste of material, labor, and clerks' time. Moreover, the knowledge that the bill of materials and the material lists have been carefully checked for accuracy and completeness has an excellent effect on the shop. It shows that the management knows what it wants and expects to get exactly what is specified and nothing else.

With a complete collection of material lists it is evident that we have a reliable basis for a system of ordering, receiving, storing, replenishing, and recording our materials, since these lists cover everything in the way of raw materials, supplies, and finished parts built in the establishment's own shop, as well as the finished parts bought outside, that go into the finished product.

Relation of Material Records to Various Departments. Figure 7 illustrates how orders for materials originate, how they are handled, and, in short, how the material records are affected by the activities of the various departments.

Orders go into the shop via Path 1 when the sales department turns over its contracts to the order depart-

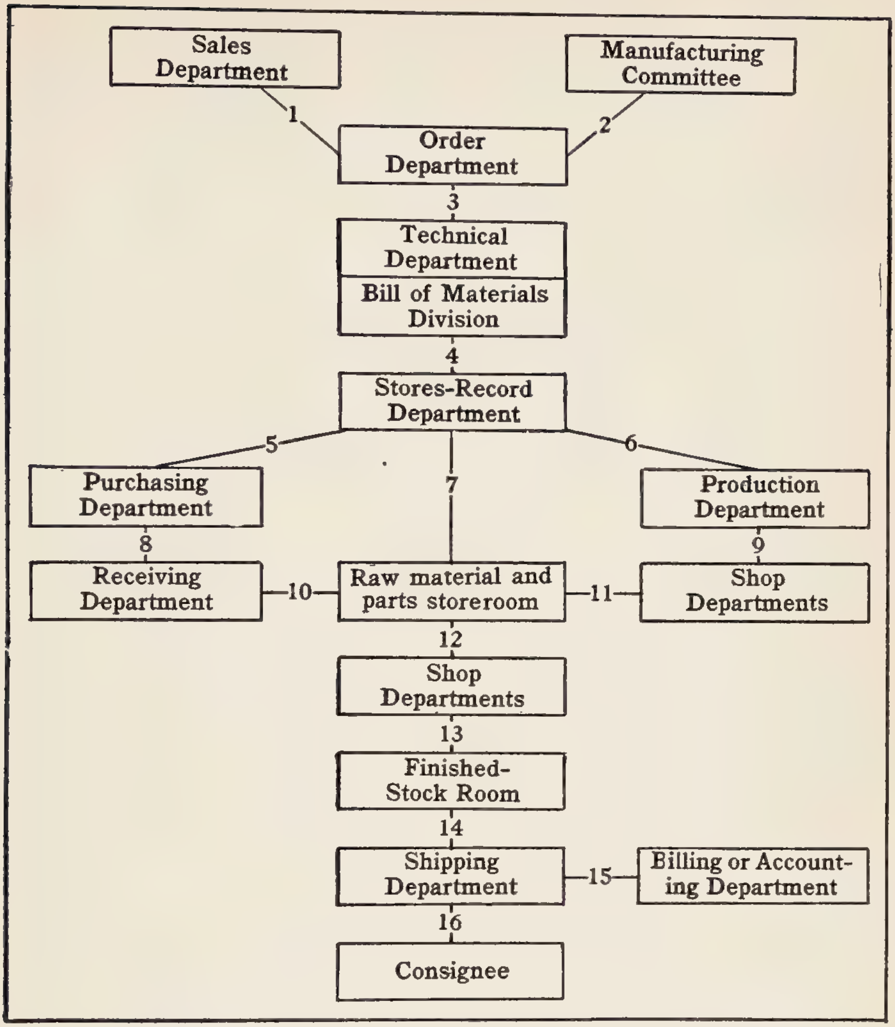


Figure 7. Chart illustrating relation and flow of material records and orders to the various departments of an industrial plant. Numbers 1 to 16 indicate paths of flow.

ment, and via Path 2 when the manufacturing committee decides on a general manufacturing program, or the making of some product or parts for stock, and advises the order department of its decisions.

Path 3 shows that these orders are then turned over to the technical department (which in a machine-building company is the designing department) where some one man, or men, is responsible for preparing bills of materials.

The bills of materials then follow Path 4 to the stores clerks in charge of records, who determine from their perpetual inventory sheets (explained later on) what materials must be bought, what materials are in stock, and what items must be made up in the shop.

The materials to be purchased are requisitioned from the purchasing agent, as shown by Path 5, and Path 7 shows how the storeroom may be instructed to reserve the parts for these orders, should this be necessary to insure that the orders may be filled as planned.

The stores-record department also starts production orders to make up detail parts on stock orders, to replenish the storeroom stock of parts, or to make special parts for orders, as shown by Path 6.

The purchasing department notifies the receiving department of outstanding purchase orders, as shown by Path 8; and the receiving department, on receipt of the goods, sends them to the stores department, as shown by Path 10, at the same time notifying the purchasing and accounting departments.

Paths 9 and 11 show how the production orders for component parts are sent to the shops, and how the parts are sent to the storeroom after having been inspected.

Path 12 shows the parts and groups issued to other shop departments for assembly and erection, after which the completed product is taken via Path 13 to the storeroom for finished stock. From here the finished product goes to the shipping department (Path 14) and thence (Path 16) to the customers.

Path 15 shows that a notification of shipment is sent to the billing or accounting department, which, in turn, notifies the customer of the shipment.

At some of these stations, carbon copies of the notification are prepared and sent to the cost, the planning, and the tracing departments, but we are not yet concerned with these departments. What we are primarily interested in here is the course-of-material and the record-of-material balances. We must not overlook our principal aims:

1. To maintain an adequate stock of materials and parts so as not to delay production.
2. To conserve in every way the money values which the stores of materials and supplies represent.

The fact that material records show a unit price for each article handled enables us to know—

1. The money value of the materials received each day or month.
2. The value of materials to be charged to work in process.
3. The value of the materials which have been converted into finished stock.

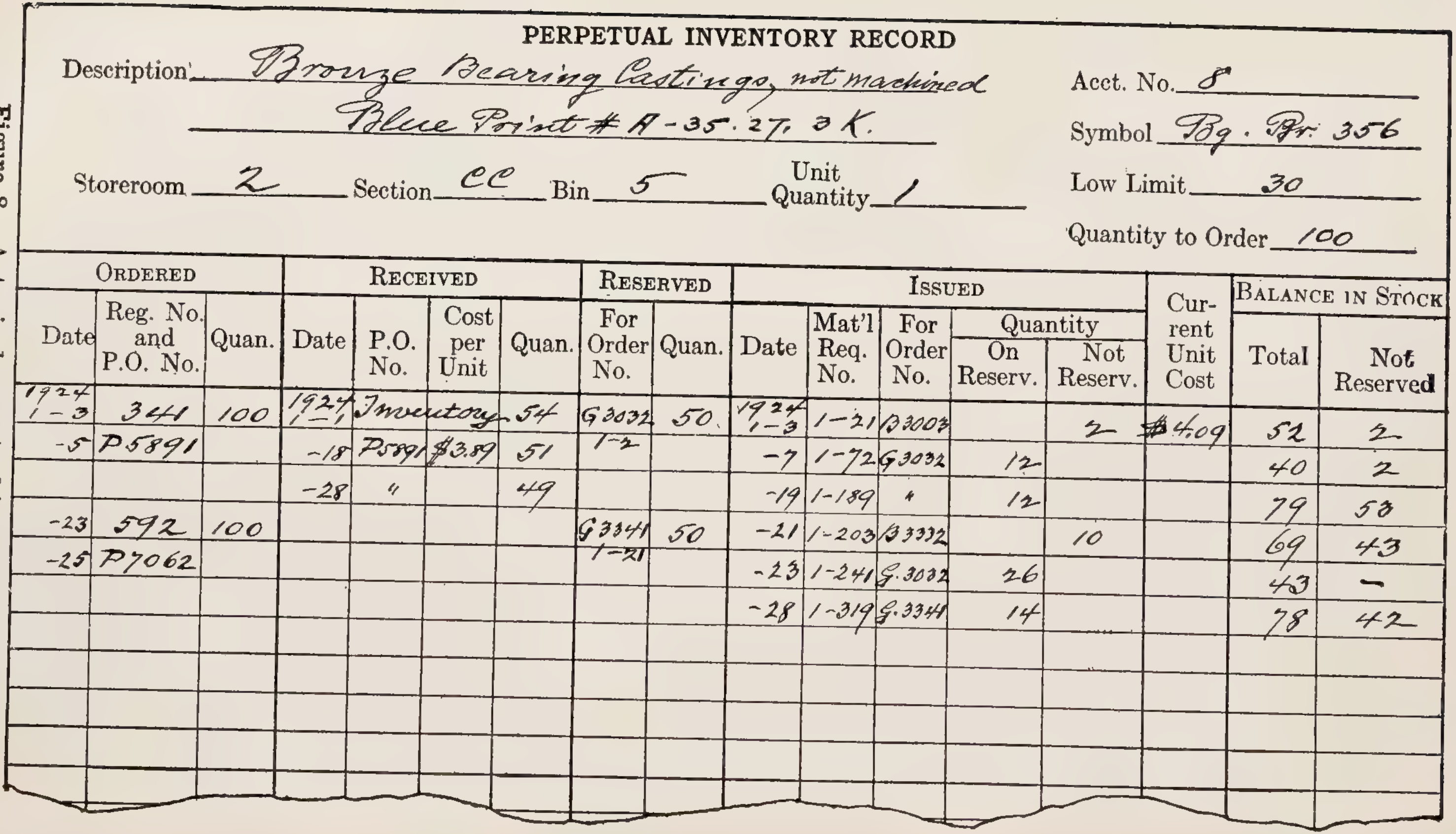
From the standpoint of accounting and statistical control (a subject to be treated in detail later on) the showing of unit prices has great value, for it puts us into a position to determine the money value of our stores of materials and supplies, of our work in process, and of our finished stock on hand. Having these money values, we can prepare a complete monthly balance sheet of the entire business instead of waiting for an annual physical inventory.

We have seen how the material lists specify the materials needed for the order that is to be filled. All these specified materials and supplies are accumulated in the storerooms, with usually some to spare in anticipation of future needs.

After the goods come in, how shall we keep account of them, both while in storage and as they are delivered to the shop? We find this question answered in the description of the perpetual inventory system.

PERPETUAL INVENTORIES OF STORES

The operation of a perpetual inventory of stores is best understood by study of the perpetual inventory record sheet, Figure 8.



PERPETUAL INVENTORY RECORD

Description Bronze Bearing Castings, not machined
Blue Print # A-35.27, 3 K.

Acct. No. 8
Symbol Bg. Br. 356
Storeroom 2 Section CC Bin 5 Unit Quantity 1
Low Limit 30
Quantity to Order 100

ORDERED			RECEIVED				RESERVED		ISSUED						BALANCE IN STOCK	
Date	Reg. No. and P.O. No.	Quan.	Date	P.O. No.	Cost per Unit	Quan.	For Order No.	Quan.	Date	Mat'l Req. No.	For Order No.	Quantity On Reserv.	Quantity Not Reserv.	Current Unit Cost	Total	Not Reserved
1924 1-3	341	100	1924 1-1	Inventory		54	G3032	50	1924 1-3	1-21	B3003		2	$4.09	52	2
-5	P5891		-18	P5891	$3.89	51	1-2		-7	1-72	G3032	12			40	2
			-28	"		49			-19	1-189	"	12			79	53
-23	592	100					G3341	50	-21	1-203	B3332		10		69	43
-25	P7062						1-21		-23	1-241	G.3032	26			43	–
									-28	1-319	G.3341	14			78	42

Figure 8. A typical perpetual inventory record.

At the top of this sheet there is a space for a description of the article. The "Account No." is used if stores are classified according to the departments which use them. For example, foundry materials and supplies may have one account number, while forge-shop materials and supplies have another.

The space for "Symbol" is filled in with either the number or mnemonic identification mark of the piece. This symbol, abbreviation, or shop number is used on withdrawal orders, time tickets, and elsewhere, to save time and space.

The "Low Limit" line shows the minimum stock to be carried. This amount and the "Quantity to Order" are filled in only when the use of the article is thoroly standardized. Until then a rubber-stamp entry, "Report to Production Department," is inserted. In fact, that procedure should be followed whenever there is any possibility that a part is in a transitional or obsolescent stage.

On the right-hand side of the sheet is shown the section of the storeroom and the bin in which it is located. Then comes the unit by which the article is measured or counted—pounds, feet, dozen, barrels, etc.

The Entries in the Inventory Record. The stores ledger has usually five groups of columns:

1. Goods ordered.
2. Goods received.
3. Goods reserved for orders.
4. Goods issued.
5. Goods available.

The entries in the first set of columns are made from copies of purchase requisitions, and from the copy of the purchasing department orders. The entries relating to goods received are made from copies of receiving clerks' reports, except the cost entries, which are taken from the purchase order or invoice.

The entries relating to goods reserved for orders are made from the material lists, whenever the amounts required on an order make this necessary. A material list may, for example, specify a few screws or rivets, which are stocked regularly in large quantities whenever the low limit is reached. It would evidently be unnecessary to

MATERIALS RECEIVED Date____

From____

Via____

Check Which	Box	Bale	Crate	Package	Bbl.	Reel	Loose

Purchase Order No.	Article	Quantity or Weight

Received by____

Delivered to____

Figure 9. Materials-received report used by receiving department to report each consignment.

STORES CREDIT

DEPARTMENT CREDITED	Req. No.
	Order No.

Quantity	Material Received	Cost Unit	Amount

Remarks____

Date____ ____
Storekeeper

Figure 10. Credit memorandum covering items returned to storeroom.

reserve such items. Experience and good judgment must guide the planning department in its decision on whether or not to reserve such items for orders.

Entries Relating to Goods Received. The receiving department should report on all materials received from the outside. Such reports sometimes include receipts from various sources on one form, and sometimes a separate sheet is prepared for each incoming consignment. The use of separate sheets is more flexible. One of these separate sheets is shown in Figure 9.

This report is usually written in manifold, an autographic register machine being frequently used. Usually one copy is kept on file in the receiving department; another is sent to the purchasing department; another to the stores-record department, so that the entry can be made on the inventory record; and sometimes another copy is sent to the production department.

Another source of receipts is the material which the shop returns to the stores department; also the parts which the shop makes up on orders for parts to be stocked and stored.

For material returned, a stores credit memorandum is issued, such as shown in Figure 10, and a somewhat similar form is used for parts manufactured and stored.

Entries Relating to Goods Issued. Goods are delivered from the storerooms when—

1. Raw materials or finished parts are issued to the shop.
2. Finished goods are shipped out by the shipping department.

Figure 11 illustrates a form of withdrawal orders for material.

In many well-organized shops, a series of these withdrawal orders for material are written in advance at the same time that the material list is prepared. They are then kept in a pocket of a large fiber-board portfolio designed to hold all the papers, drawings, lists, and other documents which relate to a given order. A withdrawal ticket is then sent to the storeroom only when the shop is ready to use the goods.

WITHDRAWAL ORDER FOR MATERIAL
To Be Used for One Item Only

Charge to Order No. Acct. No. Date

Symbol	Description of Item Wanted	Quantity	Cost Unit	Amount

Reserved	Issued	I authorize the withdrawal of this material
		Route Clerk

Figure 11. Withdrawal order for materials issued from the storeroom.

Notice, in the lower left-hand corner of the withdrawal order (Figure 11), that material which is issued for orders on which stock has been reserved is entered in a different column from that used for orders which were not reserved. The purpose is to determine accurately what part of the stock on hand is not reserved and is, therefore, available for future orders.

Also notice, in Figure 8, that, in the case there shown, there were actually 43 parts on hand on January 23, but that the reservation for 50 parts, which had been made on January 21, left no stock on hand for future orders.

Such a situation calls for attention on the part of the executive who is responsible for maintaining stores. He finds that 49 parts have not yet been delivered on an unfilled purchase order, and the purchasing department, at his suggestion, urges the supplier to deliver these promptly. Were these in stock now, there would be 42 parts available for future orders. A survey of the entire situation, however, shows him that another purchase order for 100 parts should be placed at once to make sure that production will not be delayed, and he puts in a requisition accordingly.

It is evident that even with a carefully worked out perpetual inventory system, decisions regarding material supplies cannot be made mechanically, but that probable deliveries from suppliers, probable future orders originating in the sales department, and other factors must be taken into consideration. It is well to remember that—

> **Few, if any, of the responsibilities of management can be so systematized as to make executive decisions unnecessary.**

It is also well to remember, however, that executive decisions may be facilitated as to timeliness and accuracy by a system which automatically brings important facts to the executive's attention, such as the facts which make necessary the immediate placing of a purchase order, as shown by an inventory record of the kind shown in Figure 8.

The Current Unit Cost Column. Note, in Figure 8, the Current Unit Cost column. The price shown in it is that at which this material is charged to the current orders. Knowing the unit cost, the quantities shown can be readily converted into money values to give a basis for computing the value of the inventories at any time.

The way in which the current unit cost price is computed and used, and the plan by which, thru it, the expense of maintaining the stores department is made part of the manufacturing cost, is fully explained in Appendix A, which is inserted in this manual following Executive Problem 36.

How Materials Control Reduces Investment. The system by which materials are purchased and parts are manufactured only when they have been specified on bills of material, insures that little if any useless stock will be put into the storeroom. This system does not, however, serve to keep down the investment in stock to the very lowest point, for certain parts might be ordered some months before they are needed.

On all standard parts, the purchasing and manufacturing can be based on the maximum number that may be needed during the time it takes to get or manufacture such parts. If we set such a figure as our low limit for stock, and order in moderate quantities as soon as that limit is reached, it is evident that our average investment in such stock will be held low.

In setting the low limit, the experience and judgment of the production manager and the purchasing agent, as well as the stores manager, will be used in interpreting the facts shown on the perpetual inventory record; and the estimate on probable sales will also be required. Care should be taken that the low limit be not too low. We should remember that—

> **Losses caused by production delays due to lack of material mount up far more rapidly than does the interest saved by maintaining a low stores investment.**

The procedure outlined in preceding pages not only provides for the purchase of all material needed to complete an order in the promptest way possible; it also makes use of past experience and provides a store of standard parts always ready for immediate use. It also provides a plan by which parts which will soon be required can be reserved for certain uses. When well administered, with properly set low limits, the perpetual inventory system will as nearly as possible provide materials as fast as they are required.

How Materials Control Safeguards Stores. Effective stores control not only includes well-organized storeroom equipment to protect the stores from injury or loss, but also various checks which tend to prevent waste and losses.

In the first place, the perpetual-inventory record calls for an exact statement on income and outgo. Nothing can be taken from stores without a proper withdrawal order.

These withdrawal orders are checked against the material list which has been furnished the department for each production order, and no more goods are issued on one production order than are required to make up the goods it covers.

As a further safeguard the withdrawal orders are often made out in the planning department at the same time that the material lists are prepared, and are then held until the material is scheduled to be used in production. A final safeguard is found in a check-up of the balance shown on the inventory card against the actual contents of the bins.

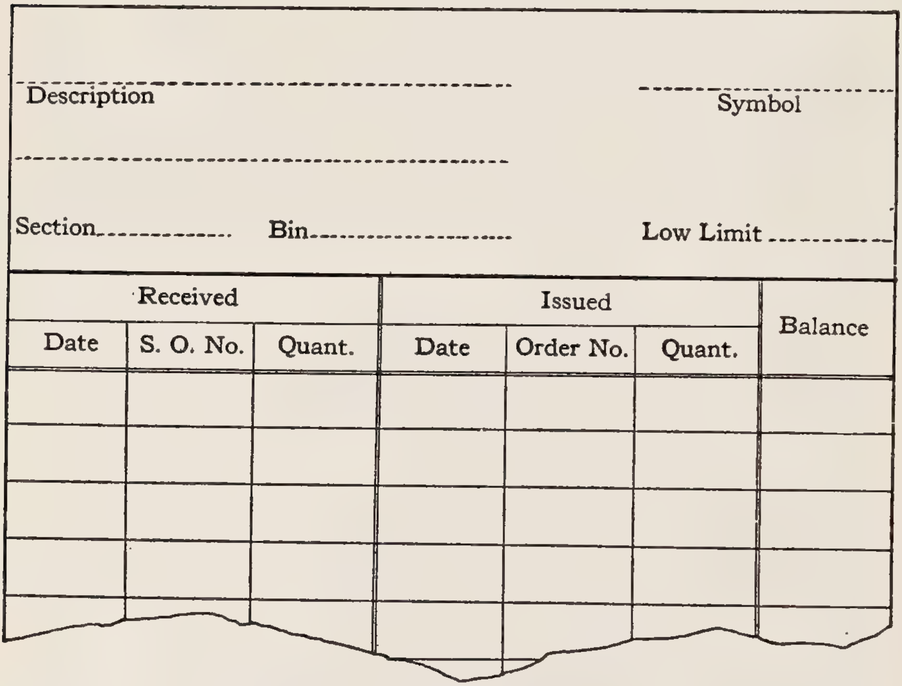
The perpetual-inventory record is, as a rule, kept in the stores-record department. On the tag attached to each bin or rack, however, a record is usually kept of income, outgo, and present supply; and whenever the stock in a bin gets low, the contents are counted or measured, and are compared with the amount shown on the tag and on the perpetual-inventory card. In addition to the foregoing check-ups, a systematic actual count of all stores is often made at least once a year.

Thus any discrepancies due to errors in keeping the records or in counting the stocks are being constantly checked up and corrected, and any thefts or other losses of stores are detected.

Properly used, the inventory system outlined in preceding pages will take care of stores with the same accuracy as an efficient accountant takes care of the financial records of a business.

An important reason why the perpetual-inventory records are kept outside the storeroom is their value in case of fire. Such records when well kept up, give an exact list on which "proof of loss" by fire can be based.

Shipping Finished Goods. Goods are withdrawn from the finished-goods storeroom on the authority of an order from the order clerk. Usually the finished-goods stock records are kept on inventory sheets similar to that shown as Figure 8, but without the complications introduced by reservations for given orders. A finished-goods stock record is shown as Figure 12.



Description .... Symbol ....

Section.............. Bin.................... Low Limit ....

Received			Issued			Balance
Date	S. O. No.	Quant.	Date	Order No.	Quant.	

Figure 12. A finished-goods inventory card. A similar card is used to inventory supplies, stationery, etc.

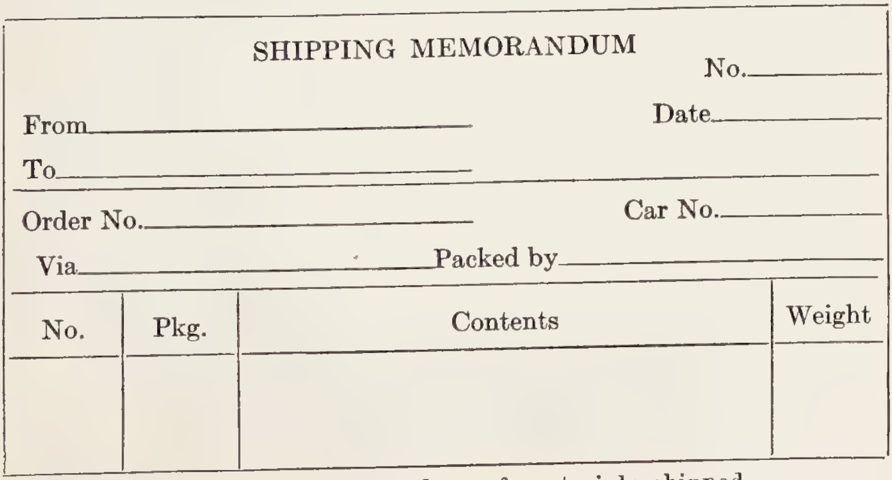
The shipping department receives the goods from stores, and packs and ships them to the consignee, usually on the authority of the same order form which released the goods from stores.

The relations between the finished-goods stock room and shipping department are always close and often the two departments are under one head.

Reports from the shipping department are often made in quadruplicate on a form like that shown in Figure 13. One copy goes to the order department and another is filed in the shipping department, while two copies go to the billing clerk, who keeps one as his authority for billing and forwards the other with the invoice to the consignee.

Under another routine, the order clerk sends triplicate copies of the shipping orders to the shipping department. The latter makes proper notations on all copies, keeps one for its own files, sends one to the order department, and the third to the billing clerk, together with a bill of lading or express receipt to forward with the invoice to the consignee.

The Man in Charge of Stores. It has been necessary to describe control of materials apart from the executives in charge, because few organizations have one executive who is responsible for all phases of this work. The designing engineers are responsible for accurate and complete bills of material; the industrial engineer is responsible for well-designed storerooms; the order department and



SHIPPING MEMORANDUM

No.________

From________ Date________

To________

Order No.________ Car No.________

Via________ Packed by________

No.	Pkg.	Contents	Weight

Figure 13. Memorandum of materials shipped.

the planning department are responsible for material lists and withdrawal orders; and the receiving and shipping departments also co-operate in the control of materials.

The perpetual-inventory record may be handled by the accounting division in connection with the cost-accounting system, or may be part of the planning-department records.

Yet even with this varied distribution of responsibility, there remains the responsibility for actual handling of stores and for their safeguarding. This responsibility, involving supervision of considerable labor and clerical help in establishments of any size, makes the storekeeper an important executive. He must be painstaking regarding detail, thoroly acquainted with all his stores and the part they play in the manufacture of the goods, and able to manage the men under him, as well as to advise with his associates.

Materials Control in Business. The perpetual-inventory system and many of the other procedures in the control of materials, may be applied in managing the stock rooms in nearly all kinds of businesses. A simple form of inventory card, similar to Figure 12, is often used.

Purchasing department practise, as explained in Part I of this manual, is also adaptable in nearly all lines of business.

The problems of purchasing and of stores, and the aims of these departments, are, fundamentally, the same in all business establishments. This is also true of the problem of planning the work.

Altho scientific planning has been developed to its highest point of efficiency in large industrial organizations, we shall see, as we analyze the practice and the principles applied in scientific planning as presented in Executive Manual 37, that smaller organizations of every kind can take advantage of the essential features of scientific planning.

The Purposes of Materials Control Are:

A. To Safeguard the Materials in the Minimum of Space, accomplished by —
  1. Placing materials where they are easily accessible and properly protected against breakage, depreciation, and theft.
  2. Arranging width, height, depth, and shape of shelves, bins, or other storage devices; also aisles and mezzanines, to economize storage space.
  3. Planning ahead of requirements, so that expansion is possible.

B. To Facilitate the Handling of Materials, accomplished by—
  1. Keeping materials which are stored in bins, in movable containers.
  2. Keeping most frequently called for articles within easiest reach.
  3. Having storage places plainly marked.
  4. Moving stored goods with most efficient handling equipment.
  5. Having storage room near center of operations.

C. To Keep Down Investment in Materials, accomplished by—
  1. A system of checks and records, which prevents overpurchasing of some things and failure to purchase others.
  2. A perpetual-inventory system with "low limits," which guides in purchasing standard materials only as fast as they will be used.
  3. A division and classification of inventory records, which calls attention to items that are little used and thus questions whether they should be stocked in the future.

D. To Do Away with Serious Causes of Delay in Production, accomplished by—
  1. Providing facilities for receiving, recording, handling, and issuing materials, parts, tools, and supplies with minimum errors and with maximum convenience.
  2. Replenishment of those parts which have to be made up in the shop in such a manner as to make most economical use of production facilities.
  3. Using a system of classification and symbols, which coordinates the purpose of the materials in the manufacturing program with their location and quantity.

The following check-up on principles and Executive Problem 36 will strengthen our grasp of the essential features of efficient control of materials. Then we shall be prepared to analyze the functions, practice, and principles applied in a modern planning department. Control thru planning, as described in Executive Manual 37, is extremely important in training for executive work. Every business has a planning problem. It is important to understand how this problem is solved by leading industrial organizations that apply scientific methods.

CHECK-UP ON PRINCIPLES

Use the following check-up to get the principles of this manual firmly fixed in mind. This will help you to handle the problem which follows. This check-up is entirely for your own personal use, so you need not send it in to the University.

	Check	
	Yes	No
1. A certain purchasing agent was scrupulously honest. He had made it his policy, however, to encourage suppliers to offer him "personal commissions," "presents," etc., all of which he then turned over to his company. His idea was in this way to get the "best deal" for his firm. Was his reasoning sound?		
2. Is the saying "Let by-gones be by-gones" a safe motto for a purchasing agent to follow in his relations with his suppliers?		
3. A requires 300 tons of castings a month. He is considering three bids: B is lowest; C, $1 a ton higher; and D, $2 a ton higher. B, however, is unreliable in keeping his promises of delivery, and A anticipates a partial shutdown of eight hours a month, on the average, if B supplies the castings. C will try to keep his delivery promises, but his furnace sometimes goes wrong and the resulting delays are likely to average four hours a month of partial shutdown. D's delivery reputation warrants an expectation of an average shutdown of but two hours a month because of lack of promised castings. A's cost accounting system shows him that these partial shutdowns cost some $800 per eight-hour day for idle time of men and equipment. If the quality is equally satisfactory, with whom should A place his orders? B? ☐ C? ☐ D? ☐		
4. A manufacturer in one of the lake ports found that he could buy glass which was suitable for his requirements from a supplier across the lake at a lower price than a local manufacturer could quote. This was true only, however, when shipments were made by boat, the rail freight rate around the lake being considerably higher. In winter, boat transportation to this port is sometimes shut down for months. There are these alternatives: 1. Each fall put in a three months' reserve stock of glass.		

	Check	
	Yes	No
2. Put in a one month's reserve and pay high freight around the lake until navigation opens. 3. Make a year's contract with the local manufacturer to supply one-third the requirements for nine months and the full requirements for the winter months. Have you enough data to select between these three plans?		
5. A manufacturing company foresees a rapid increase in demand for its product. So far as can be foreseen, the product will require no change in design or in the method of manufacture. Under these conditions, is the company justified in putting up a building specially designed for the present product, planning to put up similar units in the future as the demand increases?		
6. A butter manufacturer made a specialty of supplying print butter to his regular dealers in cartons which bore their names. Time and again the persons who packed the butter would have to stop in the midst of filling an order because not enough cartons with a given dealer's name were ready. The production manager therefore recommends that butter be sold in standard cartons only. Is this the logical solution for this difficulty?		
7. A company which manufactures a variety of products has storerooms in different parts of the plant, each storing certain materials and supplies that are most needed in the adjacent departments. It is difficult for the foremen to locate supplies that are not frequently used, for almost all such items are carried in one storeroom only. Can the loss of time in locating goods be obviated by applying one of the principles in this manual?		

Executive Problem 36

WHAT'S THE BEST BUY?

Purchasing Goods Efficiently
UNDER THE LASALLE PROBLEM METHOD

* * *

THE purchasing agent must be human to succeed. Even when he buys goods which can be rigidly specified and whose price can be figured to a penny, a broad vision and a penetrating understanding of human as well as economic factors are needed to select the most truly profitable sources of supply.

Prepared by the Research and Consultation Staff of LaSalle Extension University from an interesting problem which it has carefully investigated and analyzed.

Executive Problem 36

WHAT'S THE BEST BUY?

A morning spent in the office of a busy purchasing agent is a profitable experience for every business man. As he sees the salesmen interviewing the purchasing agent, he gets many a revealing glimpse into the causes of success and failure in salesmanship. He also gets a renewed vision of the multifarious needs of even a small industry, as requisitions for pencils, coal, and sweeping compound pass over the purchasing agent's desk, along with contracts for telephone service and fire-insurance inspection. He probably will be impressed most of all by the fact that purchasing decisions are—most of them —not a matter of mathematics so much as a careful weighing of very many factors.

You are to spend a little time in a purchasing agent's office to-day to observe his work, and you are to have the further privilege of telling how you would decide some of the questions that each day brings to him.

Your Company. You are for the day associated with the Murphy Manufacturing Company. It makes quite a wide line of conveying devices which are used in all sorts of businesses. The purchasing agent, Mr. Erskine, has contributed much to his company's prosperity by being wide awake to every factor under his observation which might contribute to the company's profits. The management has learned to respect his judgment highly and has given him wide authority.

Purchasing Lubricating Oil. The Murphy Manufacturing Company some months ago decided to standardize on the Rayol Company's lubricating oils. This decision was made only after the works manager and the purchasing agent had been convinced that this supplier could take care of all their lubricating requirements. The supplier has a local distributing branch so that an ample supply of all lubricants will always be at hand. By concentrating the purchases with this one supplier, the company makes a rather substantial price saving. The stores problem also is made much simpler, since fewer kinds of oil need be carried in stock.

Two weeks ago the purchasing agent received from the stores department a requisition for four barrels of C grade Mayne oil—oil made by a distant refinery which has no distributing warehouse within 500 miles. A little investigation has disclosed that the foreman of department D is insisting he must have this oil to lubricate a battery of high-speed machines used in his department. This oil had been recommended by the manufacturer of the machines, and has proved very satisfactory. The foreman believes that no other oil can take its place.

Mr. Erskine put this problem up to the salesman of the Rayol Company, and has learned that by mixing two gallons of Rayol F with one gallon of Rayol G, both of which the Murphy Manufacturing Company carries in stock constantly, a lubricant is obtained almost identical in viscosity and filming power to that of Mayne C grade oil. The Rayol Company recommends for these machines, however, a blend of half F and half G as being even better suited to this particular service.

The works manager has been consulted and is willing to try out the Rayol blend. He has authorized a cancellation of the purchase requisition. The department foreman, however, still protests vigorously that he needs Mayne oil for these machines. Mr. Erskine knows well that satisfaction in the use of a lubricant, and of almost everything else for that matter, depends in part on the confidence of the user. In order to convince this very skeptical foreman that he would get equivalent lubrication from Rayol oils, Mr. Erskine has sent samples of the C grade Mayne oil and of the Rayol blend to the state university testing laboratory. This morning's mail has brought a detailed result of the laboratory's test, with the general conclusion that both samples have practically the same characteristics for use in these high-speed machines.

Investigation shows that during the past year some twelve barrels of the Mayne oil have been ordered. It will cost but $48 a year more to purchase this oil for these machines. Will it pay to insist on a standardization of lubricants to such an extent as is likely somewhat to antagonize the foreman who has requisitioned this oil? How would you handle this situation?

Purchasing Lumber. Just before a decision is reached on the oil question, the card of Mr. Dennis, salesman for the Brown Lumber Company, is laid on Mr. Erskine's desk. His coming makes possible a decision on another question that has been pending for some weeks.

The Murphy Manufacturing Company uses considerable lumber in making and crating its conveyors. About one-third of this has been purchased thru the Brown Company; the relations between the two companies have been very satisfactory.

Mr. Erskine has in the past found it most profitable to purchase lumber in standard lengths and sizes. It was then cut to the required sizes in the company's shop. Mr. Dennis recently suggested that an investigation be made of the cost of cutting good, clear 2-inch stock down to the sizes which the plant needs in making up 1½-inch and 1¾-inch rollers of various lengths, of which a great many are required in the outfits the company manufactures. He suggested that considerable saving could be made by buying 2-inch squared stock cut to required lengths, all kiln dried and ready to turn. (His company has odd-sized stock which can be worked up to advantage in this way.)

This investigation was made and has shown that 15 per cent of the lumber purchased goes into these rollers. It has shown also an unexpectedly large loss in preparing the stock for the rollers from the rough lumber—a loss which cannot be avoided, since the rollers have to be of certain exact lengths and clear of all knots.

When this report was made, Mr. Dennis expected an order for squared stock at a price which would show his company a trifle more than its usual per cent of profit. Mr. Erskine, however, sent out specifications for his company's squared-stock requirements and has received a price from a dealer in a distant city which is $3 per thousand feet under the Brown price, with freight allowed to destination. This supplier is as well rated as the Brown Lumber Company and has an excellent reputation in the trade. The lumber that he offers is not exactly the same as that offered by the Brown Company, for the bid specified that some would run a little under the standard 2-inch stock dimensions. He stated in his bid that this is not a disadvantage, since the Murphy Company's 1½-inch rollers can, as a matter of fact, be turned more easily from the smaller stock than from the full-sized stock.

The lumber of both suppliers is guaranteed to be clear and to be of equal quality from a manufacturing standpoint.

Mr. Dennis has been following the situation closely. He knows that bids from other dealers are being investigated. He has come to the Murphy Manufacturing Company to make a last appeal and, as he told Mr. Brown, his employer, "to get that order which the Murphy people owe me."

When Mr. Dennis comes in, Mr. Erskine asks him if he has named his best price. "Absolutely!" is the reply. He senses that Mr. Erskine must have a lower price and at once proceeds with a vigorous sales talk in which he makes much of the following points:

1. His company has always treated the Murphy Manufacturing Company right. In giving him this business, Mr. Erskine will be certain that the orders will be filled according to the spirit as well as to the letter of the specification. To this Mr. Erskine nods his head in assent.

2. The Brown Lumber Company is located in the same city. It always has large stocks of lumber, and should an emergency arise so that it is out of 2-inch squared stock, the Brown Lumber Company can and will cut 2-inch lumber down to this specification. In doing business with the Brown Lumber Company, therefore, the certainty of supply is assured. To this also Mr. Erskine assents.

3. The quality of the lumber supplied by the Brown Company is that which goes into fine furniture and interior trim. It is always full dimensioned, for the Brown Company supplies a trade which calls for nothing but standard thicknesses of lumber. Mr. Dennis makes the most of this point, for he knows that other lumber dealers sell to a trade which does not require full-dimensioned 2-inch stock. He knows he is giving the Murphy Manufacturing Company its money's worth and he wants Mr. Erskine to realize this also.

4. Finally Mr. Dennis points out tactfully, so as to give no occasion for offense, that it was he who made the suggestion of using squared stock—a suggestion which will save the Murphy Manufacturing Company considerable money—some $700 a year. He tells his story in such a way that the purchasing agent cannot forget that the Brown Company probably would have continued to supply the Murphy Company with 2-inch lumber to be used for making rollers had this suggestion not been made. He shows clearly that he will consider it an injustice if this suggestion is used, if it results in a loss instead of a gain in business for the Brown Lumber Company. All this, however, is done so tactfully as to give Mr. Erskine no cause for offense.

What will Mr. Erskine decide to do? The saving in buying from the distant lumber company will amount to several hundred dollars a year, since several carloads of this squared stock will be required. To offset this cash advantage are the arguments which Mr. Dennis has so well presented. Should the purchasing agent give the Brown Lumber Company this business?

Appendix A

HOW UNIT PRICES ARE COMPUTED

If prices never changed and the expense of buying and storing goods was negligible, it would be a simple problem to compute current unit costs for each item carried in stock, for use in "pricing" the inventories and in computing the cost of the manufactured goods.

The prices paid for material are constantly changing, however. Moreover, the expense of purchasing, of transportation, and of receiving, storing, insuring, and handling materials is very substantial and must be recognized as contributing to the cost of goods.

In the following paragraphs we will show how these variations and additions can be accurately reflected in the current unit costs, considering first the additions that must be made to cover expenses.

The freight, express, or similar charges are as a rule added direct to the invoice cost to make the prices f. o. b. factory. This is not always practical, for many items may come in one shipment, so that it may be difficult even to estimate the freight on each. All transportation charges which cannot be added direct are distributed with the other charges included in the material burden.

The Material Burden. The sum total of all these charges—undistributed transportation (if any), purchasing, receiving, insurance, and stores expenses—for, say, a year, is divided by the total amount purchased during this period. This gives the ratio which the expense of buying and handling materials bears to the total invoice price, a ratio which is expressed as a per cent of the invoice price. For example, suppose the expenses amount to $6,000 during a six-month period, and the purchases for the same period are invoiced at $200,000, including freight. Dividing 6,000 by 200,000, we get .03 or 3 per cent.

This percentage is called the material-burden rate. The burden worked out from last year's experience may be used to estimate this year's burden very closely. This per cent is then added to the cost of all goods received to get the total cost which these goods stand us.

This procedure is recognized among accountants and appraisers as not only legitimate but correct, inasmuch as inward freight and the cost of buying, receiving, and storing material increase the replacement value of material. In a going concern the fact that goods are on hand ready for manufacture is a real asset, and the expense involved in getting the goods is a real addition to their value, while if these expenses are charged to general expense accounts, we are actually undervaluing our stores.

In some industries, goods of extremely varied kinds are needed. Then material-burden rates must be computed for the different classes of goods. A company making electrical machinery may need considerable silver wire for brazing, and also bulky cotton sleeving for insulation. To handle and store $100 worth of cotton sleeving may cost ten times as much as to buy and store $100 worth of silver wire. In such a case the per cent of burden should be computed separately for such expensive goods as silver and such bulky goods as cotton insulation.

In computing unit prices, it is usually necessary to figure to four significant figures to get the necessary accuracy. Copper wire, for example, may be invoiced at $.24 per pound; the freight may add $.52 per cwt., or $.0052 per pound; while a material burden of 2.3 per cent is expressed with fair accuracy as $.0055 per pound. This copper wire should then be inventoried at a unit cost price of $.2507 per pound.

How to Average Varying Cost. Suppose we start the year with 800 tons of foundry pig iron on hand which cost $20 a ton, including the material burden. Suppose during January we buy 300 tons at $19.50, later 200 tons at $20.25, and finally 300 tons at $21. Suppose we have used 1,000 tons during the month, some from one lot, some from another, just as came handiest to the foundry foreman. At what price for pig shall we "cost" the January castings? What shall be done about February?

There are two general methods. In one, accurate account is kept of the amounts made from the different-priced materials. The first 800 tons of castings turned out during January would be considered as made up out of the $20-per-ton stock and "costed" accordingly. The remainder of the January castings (200 tons) would be considered as made out of the $19.50 stock.

In February the first 100 tons of castings made would be costed at $19.50, the next 200 tons at $20.25, etc.

When prices change rarely, this method is not difficult to apply. A unit price is established for each lot received. For purposes of accounting, material is considered as being issued in the order of its receipt. After a lot carried at one price is exhausted, the unit price which applies to the next lot is used until it too is exhausted. Often this means that material for one order is priced at two unit prices.

This plan permits very close balancing of accounts between stores inventory, the stores charges on shop requisitions, and the purchase records.

Under the above plan, however, when prices fluctuate, often it not only becomes difficult to keep track of the amounts of material that should be charged out at different unit prices, and to compute all these prices, but the costs of the finished goods cannot be compared fairly since to-day's goods may be made out of a batch of high-cost material and to-morrow's out of a lot bought at bargain prices. Various plans of averaging prices so as to use one unit price for at least a month seek to overcome these difficulties.

In one of the best plans the average unit cost each month is based on the purchases for as many months back as materials are purchased ahead of use. For example, if the usual stock on hand and on order averages a two months' supply, the purchases for the preceding two months are considered in arriving at each month's unit price. When, however, as in the example we have here, the stock carried on hand averages one month's supply or less, only the preceding month's purchases are considered.

In this example, then, during January, castings would be costed at $20 a ton—the average December price. During January 800 tons were purchased for a total of $16,200, or an average of $20.25 a ton, and this would be the price at which February castings would be costed.

It will be seen that under this plan the price at which the material is charged against orders is just about the average price that was paid for it, and this price keeps in step with the trend of the market.

When market price changes so much that the unit cost prices are seriously at variance with present values, as is often the case when prices drop rapidly during a period of deflation, the inventory values are adjusted to the actual value by charging the difference to the profit and loss account.